Aims and Scope

Educational Technology & Society is a quarterly journal published in January, April, July and October. Educational Technology & Society seeks academic articles on the issues affecting the developers of educational systems and educators who implement and manage such systems. The articles should discuss the perspectives of both communities and their relation to each other:

- Educators aim to use technology to enhance individual learning as well as to achieve widespread education and expect the technology to blend with their individual approach to instruction. However, most educators are not fully aware of the benefits that may be obtained by proactively harnessing the available technologies and how they might be able to influence further developments through systematic feedback and suggestions.
- Educational system developers and artificial intelligence (AI) researchers are sometimes unaware of the needs and requirements of typical teachers, with a possible exception of those in the computer science domain. In transferring the notion of a ‘user’ from the human-computer interaction studies and assigning it to the ‘student’, the educator's role as the 'implementer/manager/user' of the technology has been forgotten.
- The aim of the journal is to help them better understand each other's role in the overall process of education and how they may support each other. The articles should be original, unpublished, and not in consideration for publication elsewhere at the time of submission to Educational Technology & Society and three months thereafter.

The scope of the journal is broad. Following list of topics is considered to be within the scope of the journal:


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Table of contents

### Special issue articles

**Guest Editorial: Advanced Learning Technologies**  
Demetrios G. Sampson, J. Michael Spector, Ignacio Aedo and Nian-Shing Chen  
1-2

**Are One-to-One Computers Necessary? An Analysis of Collaborative Web Exploration Activities Supported by Shared Displays**  
Chia-Jung Chang, Chen-Chung Liu and Yan-Jhih Shen  
3-13

**Curriculum-guided Crowd Sourcing of Assessments in a Developing Country**  
Imran A. Zualkernan, Anjana Raza and Asad Karim  
14-26

**PEDALE - A Peer Education Diagnostic and Learning Environment**  
Johannes Konert, Kristina Richter, Florian Mehm, Stefan Göbel, Regina Bruder and Ralf Steinmetz  
27-38

**Teaching Web Security using Portable Virtual Labs**  
Li-Chiou Chen and Lixin Tao  
39-46

**Semantic Linking of Learning Object Repositories to DBpedia**  
Manuel Lama, Juan C. Vidal, Estefania Otero-Garcia, Alberto Bugarin and Senén Barro  
47-61

**Learning-by-Teaching: Designing Teachable Agents with Intrinsic Motivation**  
Guopeng Zhao, Ailiya and Zhiqi Shen  
62-74

**Self-regulated Workplace Learning: A Pedagogical Framework and Semantic Web-based Environment**  
75-88

### Full length articles

**Youth as Design Partners: Age-Appropriate Websites for Middle and High School Students**  
Anthony S. Chow, Kathelene McCarty Smith and Katherine Sun  
89-103

**Raise Your Hands or Hands-on? The Role of Computer-Supported Collaborative Learning in Stimulating Intercreativity in Education**  
Lien Mostmans, Chris Vleugels and Stijn Bannier  
104-113

**Why do Individuals Use e-Portfolios?**  
Mu-Yen Chen, Francis Mou-Te Chang, Chia-Chen Chen, Mu-Jung Huang and Jing-Wen Chen  
114-125

**The Searching Effectiveness of Social Tagging in Museum Websites**  
Chung-Wen Cho, Ting-Kuang Yeh, Shu-Wen Cheng and Chun-Yen Chang  
126-136

**A Multivariate Model of Factors Influencing Technology Use by Preservice Teachers during Practice Teaching**  
Shih-Hsiung Liu  
137-149

**Designing a Personalized Guide Recommendation System to Mitigate Information Overload in Museum Learning**  
Yong-Ming Huang, Chien-Hung Liu, Chun-Yi Lee and Yueh-Min Huang  
150-166

**Assessment of 3D Viewers for the Display of Interactive Documents in the Learning of Graphic Engineering**  
Basilio Ramos Barbero, Carlos Melgosa Pedrosa and Esteban García Maté  
167-180

**Using Podcasting to Facilitate Student Learning: A Constructivist Perspective**  
Dick Ng’ambi and Annette Lombe  
181-192

**Evaluation of Teaching the IS-LM Model through a Simulation Program**  
Maria del Pópulo Pablo-Romero, Rafael Pozo-Barajas and Maria de la Palma Gómez-Calero  
193-204

**Development of a Web-based System to Support Self-Directed Learning of Microfabrication Technologies**  
Min Jou and Yu-Shiang Wu  
205-213
Peer Evaluation in Blended Team Project-Based Learning: What Do Students Find Important?  
Hye-Jung Lee and Cheolil Lim  
214-224

Life Planning by Digital Storytelling in a Primary School in Rural Tanzania  
Marcus Duveskog, Matti Tedre, Carolina Islas Sedano and Erkki Sutinen  
225-237

Enabling Problem Based Learning through Web 2.0 Technologies: PBL 2.0  
Efthimios Tambouris, Eleni Panopoulou, Konstantinos Tarabanis, Thomas Ryberg, Lillian Buus, Vassilios Peristeras, Deirdre Lee and Lukasz Porwol  
238-251

An Electronic Library-based Learning Environment for Supporting Web-based Problem-Solving Activities  
Pei-Shan Tsai, Gwo-Jen Hwang, Chin-Chung Tsai, Chun-Ming Hung and Iwen Huang  
252-264

Is Teacher Assessment Reliable or Valid for High School Students under a Web-based Portfolio Environment?  
Chi-Cheng Chang and Bing-Hong Wu  
265-278

E-learning Systems Support of Collaborative Agreements: A Theoretical Model  
Sandra Aguirre and Juan Quemada  
279-295

Social Networks and Performance in Distributed Learning Communities  
Rita Cadima, Jordi Ojeda and Josep M. Monguet  
296-304

A Framework for Simplifying Educator Tasks Related to the Integration of Games in the Learning Flow  
Ángel del Blanco, Javier Torrente, Eugenio J. Marchiori, Iván Martínez-Ortiz, Pablo Moreno-Ger and Baltasar Fernández-Manjón  
305-318

A Cognitive Apprenticeship Approach to Facilitating Web-based Collaborative Problem Solving  
Fan-Ray Kuo, Gwo-Jen Hwang, Szu-Chuang Chen and Sherry Y. Chen  
319-331

An Exploratory Study of the Cultural Habits Change Process Triggered by the Use of IT: A Faculty Student Knowledge-Sharing Platform Case Study  
Mei-Lien Young  
332-343

Transforming Online Learning through Narrative and Student Agency  
Robb Lindgren and Rudy McDaniel  
344-355

An Investigation of Teaching and Learning Interaction Factors for the Use of the Interactive Whiteboard Technology  
Tsung-Ho Liang, Yueh-Min Huang and Chin-Chung Tsai  
356-367

A Project-based Digital Storytelling Approach for Improving Students’ Learning Motivation, Problem-Solving Competence and Learning Achievement  
Chun-Ming Hung, Gwo-Jen Hwang and Iwen Huang  
368-379

Disruptive Pedagogies and Technologies in Universities  
Terry Anderson and Rory McGreal  
380-389
Guest Editorial: Advanced Learning Technologies

Demetrios G. Sampson1, J. Michael Spector2, Ignacio Aedo3 and Nian-Shing Chen4

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The 11th IEEE International Conference on Advanced Learning Technologies was hosted at the University of Georgia in Athens, Georgia July 6-8, 2011. The Conference Co-Chairs were Prof. J. Michael Spector (who was at UGA-College of Education at the time) and Prof. Kinshuk (Athabasca University – School of Computing and Information Systems). The Program Chairs were Prof. Ignacio Aedo (Universidad Carlos III de Madrid), Prof. Nian-Shing Chen (National Sun Yat-sen University of Taiwan), and Prof. Demetrios Sampson (University of Piraeus, Greece). The conference theme was “Cloudy with a Slight Chance for Gain,” which was intended to capture the dual emphasis on cloud computing for education and advanced assessment technologies. Other topics of interest included digital gaming technology, intelligent learning systems, and much more. Paper submissions represented more than 25 countries around the world. ICALT 2011 received 244 submissions (211 full papers, 24 short papers and 9 posters) and 60 of them were accepted as full papers (24.59%). The best seven of those are presented in this special issue of Educational Technology & Society. It is our pleasure to briefly introduce these seven papers and conclude with our own reflections.

The first paper entitled “Are one-to-one computers necessary? An analysis of collaborative Web exploration activities supported by shared displays” is by Chia-Jung Chung, Chen-Chung Liu, and Yan-Jhin Shen, all of whom are from Taiwan. This paper is consistent with the dual theme of the conference emphasizing the role of cloud-based resources and assessment. The study these authors report involves the effect of having a shared computer with a small group exploring Web resources versus having one-to-one computers which shared displays. The findings suggest that the one-to-one computer treatment with shared displays was more effective in promoting collaboration and elaboration of the findings of Web explorations.

The second paper entitled “Curriculum-guided crowd sourcing of assessments in a developing country” is by Imran Zualkernan (UAE), Anjana Raza (Pakistan), and Asad Karim (Pakistan). As the title directly implies, this paper also addressed both themes of the conference. The authors report the findings of an exploratory study aimed at determining if teachers in a developing country were able to create high quality, multiple-choice questions for elementary school students. The notion of crowd sourcing assessments was introduced to explore the willingness of the teachers to share their assessment items. Not surprisingly, the findings suggest that those with a readiness for adoption of new assessments had better attitudes and enjoyed the activity. However, there was no clear indication of which factors contributed to high quality items, although most of the teachers willingly embraced the activity.

The paper entitled “PEDALE: A peer education diagnostic and learning environment” was contributed by Johannes Konert, Kristina Richter, Forian Mehm, Stefan Göbel, Regina Bruer, and Ralf Steinmetz, all from Germany. This paper focused primarily on the advanced assessment technology theme. The problem addressed involved dynamic formative assessment – specifically, how diagnosis and learning can be merged consistently and meaningfully so as to support both teachers and students in the context of an ongoing learning process. The authors present a model that integrates peer assessments into an adaptive diagnostic learning environment is presented. The focus of the research was on mathematics with the notion that the framework would generalize to other domains. The authors note that integrating a social network in the classroom environment is a vital element that warrants further investigation.

The article entitled “Teaching Web security using portable virtual labs: us by Li-Chiou Chen and Lixin Tao, both from the USA. The contribution is focused on security issues arising in the context of cloud-based activities. The authors created a tool called Secure Web Development Teaching (SWEET) that introduces basic security concepts and best practices for use in developing Web applications. SWEET includes tutorials, teaching modules with virtual activities, and projects aimed at ensuring secure application development and implementation. The paper describes the design of the tool and the resources it provides. The results of using SWEET are generally positive, including adopting by a number of institutions.
The contribution entitled “Semantic linking of learning object repositories to DBpedia” by Manuel Lama, Juan Vidal, Estefanía Otero-García, Alberto Bugarín, and Sennen Barro, all of whom are from Spain, is focused primarily on a method to enhance cloud-based resources by making better use of large repositories of learning objects. The authors present a way to automate learning object classification in a repository containing more than 15 million learning objects represented according to the IEEE Learning Object Metadata (LOM) standard. As is typical in such large repositories, many objects were not correctly classified, which presents a challenge for automating search and access algorithms. The solution approach introduced in this paper involves the use of a linked data repository, DBpedia, to improve the graph-based filtering algorithm. Results are generally positive in that the approach found good solutions in more than 700,000 categories and is extensible to other repositories.

The paper entitled “Learning-by-teaching: Designing teachable agents with intrinsic motivation” by Geupeng Zhao, Ailiya, and Zhiqi Shen from Singapore explores the feasibility of pedagogical agents with regard to student motivation. While pedagogical agents have been found to have some promise with regard to supporting learning, this paper is aimed at support for motivation, which is an important and underexplored area of investigation. The authors implemented and tested a motivated teachable agent using a goal-oriented approach that explicitly accounted for teachability, practicability and affectivability. The authors present a use-case study to illustrate the approach, which was based in self-determination theory, and its effects with two groups of primary school students in Singapore.

The final paper entitled “Self-regulated workplace learning: A pedagogical framework and semantic environment” is by Melody Didaty (Canada), Dragan Gavres (Canada), Jelena Jovanović (Serbia), Kai Pata (Estonia), Nikola Milikić (Serbia), Teresa Holocher-Ertl (Austria), Zoran Jeremić (Serbia), Liaqat Ali (Canada), Aleksandar Giljanović (Canada), and Marek Hatala (Canada). This paper explores the role of self-regulated learning in the context of workplace-based learning. While there is much written about self-regulated learning in online learning environments, little has been reported that has focused specifically on workplace-based learning. The focus is on intentional workplace learning with an acknowledgment that incidental and informal learning also occurs in the workplace. The reason for focusing on intentional learning is that is an important aspect of the workplace and it is precisely where improving self-regulation skills is likely to have a significant and measurable effect. The solution is called Learn-B and consists of support for harmonizing individual and organizational goals, aligning individual learning goals, and supporting the social nature of workplace learning. Findings reported are generally positive, and additional research is suggested in specific areas (e.g., how the organization nurtures or fails to nurture trust among employees).

These seven papers reflect a wide variety of perspectives from around the globe on what cloud-based resources hold for the future of learning and how new technologies are needed and now possible to support learning in a cloud-intensive environment. We hope you enjoy this special issue and you explore more contributions to these research areas in next ICALT conferences.
Are One-to-One Computers Necessary? An Analysis of Collaborative Web Exploration Activities Supported by Shared Displays

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ABSTRACT

Collaborative web exploration, in which learners work together to explore the World Wide Web, has become a key learning activity in education contexts. Learners can use a shared computer with a shared display to explore the web together. However, such a shared-computer approach may limit active participation among learners. To address this issue, this study proposed to use one-to-one (1:1) computers, connected to the shared displays through a groupware, to facilitate the collaborative tasks. This study analyzed the exploratory activities and discussion dialogues obtained when students were exploring the web with the shared computer and the 1:1 shared-displays. The results show that with only shared computers student discussions did not coherently facilitate the group to judge information or make group decision. On the contrary, when using the 1:1 computers with the shared displays, students collected and surveyed richer information on the web. The approach could support students to take part in individual exploration and join the group activity based on their individual exploration. Compared to the shared-computer approach, students demonstrated a more elaborative discussion patterns in which students clarify and self-reflect upon the information they found to judge the value of the information and make group decision.

Keywords

One-to-one, Shared display, Interaction pattern, Collaborative web exploration activities

Introduction

Collaborative learning has gained significant attention to improve student learning in educational approaches (Dillenbourg & Traum, 2006; Liu & Lee, 2005; Zurita & Nussbaum, 2004). Among various scenarios of collaborative learning, collaborative web exploration, where learners work together to explore the Web, has become a key learning activity in educational contexts because it facilitates learners with greater access to various information and greater opportunities to learn collaboratively with peers (Lee, 2005; Morris & Horvitz, 2007). Such collaborative learning activities often takes place in various situations, such as problem solving (Kuiper, et al., 2009), learning in the library (Twidale, Nichols, & Paice, 1997), proposal planning (Morris, 2008) and school coursework (Amershi & Morris, 2008; Morris, Lombardo, & Wigdor, 2010). Learners could thus experience knowledge restructuration by exploring, sharing and discussing information and thoughts (Paul & Morris, 2009). Due to the educational benefit of the collaborative web exploration, various designs of face-to-face web exploration groupware that support learners to search the web information together was proposed. With the facilitation of groupware, learners can share their search results and work together on the results to collaboratively solve problems (Amershi & Morris, 2008; Aneiros & Estivill-Castro, 2005). Such a groupware is based on shared-display design, which means users could simultaneously use of easy input devices such as computer mice to collaborate in a shared computer with a single shared display (Stewart et al., 1999; Morris, Paepeke, & Winograd, 2006; Ryall et al., 2004; Scott et al., 2003). For instance, in the study by Ryall et al. (2004), Morris et al. (2006), they utilized a shared computer with an interactive table with multi-touch function to support face-to-face collaborative web exploration. Such a shared-display approach could promote the shared understanding of the task among learners (Liu & Kao, 2007, Liu et al., 2009) and increase the awareness of members’ work status (Dietz & Leigh, 2001; Morris, et al., 2010).

However, previous study by Issroff and del Soldato (1996) indicated that the shared-computer approach may limit active participation among group members due to the lack of control on the shared computer. Moreover, the web exploration activity is a complicated cognitive process involving various exploratory activities, such as information of searching, clarification, judgment, and reading (Hill, 1999; Tu, Shih, & Tsai, 2008). In other words, the collaborative web exploration activities are a complicated activity dynamics including individual and group activities. Hence, the limited accessibility of the shared computer impedes learners to integrate their search results...
with the group exploration activity (Amershi & Morris, 2008). As a result, the learners may not be able to extend to broader scopes of perspectives through the collaborative web exploration activities. Moreover, such a lack of accessibility can make members frustrated toward interaction because some learners will dominate the searching activity and ignore other member’s ideas (Amershi & Morris, 2008). Hence, there is a strong need to provide an effective mechanism which supports all learners to cohesively explore on the web together. In other word, the mechanism can not only accommodate individual needs, but also facilitate the whole group to explore the web.

One-to-one (1:1) computers such as personal laptop computers, smart phones and tablet PCs may be used to address the above issue. Such mobile computers interconnected by a wireless network can be applied to improve coordination, communication, organization of materials, negotiation and interactivity in classrooms (Zurita & Nussbaum, 2004). Several studies had proposed innovative systems to support collaborative web exploration with the 1:1 computers. For instance, WebSplitter (Han et al., 2000), CoSearch (Amershi & Morris, 2008), and CoSense (Paul & Morris, 2009) enable group members to use such 1:1 computers to conduct search activities on one shared computer. However, in such a 1:1 approach, it was difficult for learners to share information and be aware of other members’ work status because learners may be overly pre-occupied with their computers (Liu et al., 2009). This may interfere with social interaction that is necessary for building mutual understanding (Amershi & Morris, 2009; Liu & Kao, 2007).

Due to the aforementioned limitations of the shared-computer and 1:1 approaches, this study thus proposed a 1:1 shared-display approach to resolve the limitations. With the 1:1 shared-display approach, each member can utilize 1:1 computers to search and read web resources, while collaborating with others members on the shared display to explore the web collaboratively. It is hoped that learner’s individual exploration and group interaction during the web. However, the group dynamics is complex when both shared-displays and 1:1 computers were applied. Therefore, it is necessary to analyze the influence of the 1:1 shared-display approach on individual and group activities. Previous study by Lee (2010) has investigated the influence of the shared display on the collaborative web exploration. However, whether the 1:1 computers are necessary to implement an effective collaborative web exploration activity and how the 1:1 computers may influence such an exploratory activity is still not clear. To this end, this study conducted an empirical study to examine how the learners collaboratively explore the web in the 1:1 shared-display approach by answering the following research questions:

- Do students take different exploratory activities when they explore the web with 1:1 computers?
- How the 1:1 computers may influence students’ discussion process?
- What are the benefits of using 1:1 computers with shared displays to support collaborative web exploration?

Method

Participants and the exploration activity

This study conducted an experiment to investigate how shared-computer and 1:1 shared-display approaches influence the collaborative web exploration activity. The participants were nine graduate students from a course entitled ‘The theory and practice of mobile learning’ at a university in Taiwan. Two of the participants were female while the others were male. The students were divided into three groups of three. Each group took part in two collaborative web exploration activities to answer specific questions given by the teacher. The questions involved in the two activities were “how mobile technologies can be applied to support learning?” and “how groupware can be applied in classroom learning contexts”. The teacher firstly introduced the background of the two questions. To obtain an answer to the questions, the students then had to 1) search for related studies, 2) analyze pros and cons of collected information, and 3) propose suggestions of future development. By the end of activity, each group had to present their conclusion to the class. Each activity lasted three hours. The students used different approaches to explore the answers of the questions on the web.

Instruments

The shared-computer and one-to-one shared-display approaches

The shared-computer and 1:1 shared-display approaches were used to facilitate the above activities (shown as Figure 1 and 2). The two approaches were both equipped with a shared display groupware which involves a shared
computer and a shared display. The groupware was developed by Liu et al. (2010). The shared display groupware provides a mind map as the interface for each group to share exchange and link information they found on the web because mind maps are helpful to promote the integration and evaluation of information (Liu et al., 2005). The mind map support exploration with several components detailed below:

- **Concept node:** learners can add a concept as a node to indicate the keywords they used to search the web.
- **File node:** System supports learners to store information they found in different file types, such as PDF, Word, Notepad, Image and Webpage.
- **Comment node:** Learners can summarize, reflect upon the information they found by adding a comment node in the mind map.
- **Links:** Learners can link any two nodes of any type that they consider to be related.

**Figure 1.** The shared-computer approach  
**Figure 2.** The 1:1 shared-display approach

**Figure 3.** A mind map developed by a student group while exploring the web

Figure 3 shows an example of such a mind map generated through the groupware. The group firstly searched for information on the web and found an important web page (the earth icon). From the page, they extracted important concepts indicated by this page and inserted these concepts onto the map (green ovals). By search with these concepts, the students group further found two papers (PDF icon). After reading the two papers, they wrote down comments on the two papers (post-it icon). Because the map displays all the steps that the students took to explore the web, it could help us to understand group exploratory process in the two approaches. In both of the two approaches, the students could use the groupware. The only difference between the two approaches is that the students could use their own laptop computers to operate the groupware in the 1:1 shared-display approach while they could only use the groupware through the shared computer in the shared-computer approach.
Data collection

This study collected three types of activity records to answer the research questions. These activity records include groupware activity logs, onscreen videos, and activity video as detailed below:

- **Onscreen videos**: The students could conduct several types of exploratory activities in the two approaches. More specifically, they could search on the web, read files they found, and use groupware individually or with peers. In order to capture the students’ exploratory activities on computers, each shared-computer and 1:1 computer were installed with an onscreen recorder. The onscreen videos recorded can show how each student conduct these exploratory activities.

- **Groupware activity logs**: During the collaborative web exploration activity, the groupware recorded automatically participants’ activities on the mind map. These activities include adding, deleting, and linking concept nodes, as well as browsing and uploading file nodes. These activity logs may reflect how the students organize information during the activity.

- **Activity videos**: Three video cameras were mounted on the ceiling of the classroom and connected to a monitoring system. Each camera was set to point to a group workspace to videotape group discussion activities. The students did not feel the cameras intrusively interrupt their discussion activities as the cameras were hidden on the ceiling of the classroom.

Data analysis

To understand how the two different approaches support group to organize knowledge, the groupware activity logs were analyzed to obtain more comprehensive activities. Nine types of activities were identified from activity logs, including adding/deleting a concept, adding/deleting a comment, adding/deleting a link between nodes and uploading/deleting/browsing a file. On the other hands, to obtain a better understanding of group activity, the study observed the time that the students spent on different tasks from the onscreen videos. The observation was made to understand how the students performed group and individual activities on the shared computers and 1:1 computers. More specifically, the time that the students spent on browsing web, reading files, using groupware were extracted from the videos. By doing so, we can obtain a better understanding of how individual students work together to explore the web in the two approaches.

In addition, the study also analyzed the dialogues in the activity videos to understand the group interactions in the two approaches. The dialogues were segmented into threads which was a basic unit of analysis of this study. A sequence of utterances in the dialogues was considered as a thread when these utterances were related to a specific topic. All the dialogue threads were classified into categories based on their functions during exploration. The classification of dialogue threads was conducted by two researchers. Disagreements were resolve upon discussion. The inter-coder reliability (agreement) for the classification was 93.3%, indicating that the analysis was adequately reliable.

The study further analyzed the sequential pattern of the above dialogue threads to reveal the group interaction pattern, because the sequential pattern analysis was an effective method to discover the transition relationship between different activities (Yamauchi, Yokozawa, Shinohara, & Ishida, 2000; Ezeife & Lu, 2005; Wasson & Mørch, 2000). The patterns were represented as a transition diagram depicting the transition probability between any two thread types. More specifically, the transition probability from thread A to thread B is the ratio of “the frequency of A to B” to “the frequency of B”. Such pattern could illustrate the transition between different threads to reveal the progress of the group discussion.

Result and Discussion

Exploratory activities

Table 1 shows the results of time used for different exploratory activities among groups in the two approaches. Regarding the searching activity, the students could only search on the web together in the shared computer approach as they did not have 1:1 computers. They spent a considerable portion of time on searching on the web together.
Conversely, the students often searched for information on the web individually when they used the 1:1 shared-display approach. They rarely joined together to search. The results reflect that the collaborative web exploration activity may involve both group and individual activities. However, with the shared computer approach, the student could not conduct individual activities as they did not have 1:1 computers to support their individual activities.

Table 1. The time distribution of exploratory activities in the two approaches

<table>
<thead>
<tr>
<th>Approach</th>
<th>Shared-computer</th>
<th>1:1 shared-display</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group</td>
<td>G1</td>
<td>G2</td>
</tr>
<tr>
<td>Searching the web together</td>
<td>15%</td>
<td>3%</td>
</tr>
<tr>
<td>Searching the web individually</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Reading files together</td>
<td>28%</td>
<td>57%</td>
</tr>
<tr>
<td>Reading files individually</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Using groupware together</td>
<td>54%</td>
<td>38%</td>
</tr>
<tr>
<td>Using groupware individually</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Others</td>
<td>3%</td>
<td>2%</td>
</tr>
<tr>
<td>Total</td>
<td>100%</td>
<td>100%</td>
</tr>
</tbody>
</table>

Regarding the reading activity, the students in the shared-computer approach spent much time on reading files together as they could not read files individually. On the contrary, in the 1:1 shared-display approach, the students demonstrated frequently individual reading activities. More specifically, they spent more time on reading individually than they did together. Such results may be because the reading paces of the students are different. In the shared-computer approach, the students were restricted by the device and have to compromise with others while reading information. On the contrary, in the 1:1 shared-display approach, they could read information according to their own reading pace. Such results support that in the collaborative web exploration activity, the 1:1 computers may be necessary to accommodate the needs of different students.

Regarding the groupware activity, the students in the shared-computer approach spent considerable time on using groupware together. However, in the 1:1 shared-display approach, their groupware activities were conducted in two manners. The analysis of the activity videos found that the students firstly used the groupware to manage information they found and wrote down their comments on the information. The students spend about 28% ~ 47% time on such activities. They then joined together to use the groupware to integrate and link different information and the perspectives from all group members. However, the students only spent very limited time on such a use of groupware (4%~7%). On the contrary, without the 1:1 computers, the students in the shared-computer approach used the groupware by taking turns, which led to long waiting time. Such results suggest that 1:1 computers may have transformed the dynamic of the collaborative activity into a two-phases learning activity. More specifically, the students firstly took part in individual exploration and then joined the group activity based on their individual exploration.

Groupware activity

Table 2 shows the groupware activities of three groups in the shared-computer and 1:1 shared-display approaches. The results reveal that overall the student groups used groupware more frequently in the 1:1 shared-display approach than they did in the shared-computer approach. More specifically, group 2 and group 3 added and deleted more concept nodes and browsed more files in the 1:1 shared-display approach. However, group 1 did not demonstrate profoundly different groupware activities in the two approaches.

Such results may be attributed to the autonomy promoted by the 1:1 computers. Because the students did not have individual learning device in the shared-computer approach, it is difficult for them to join the mind mapping activity. Hence, they performed few knowledge organization activities in the shared-computer approach. On the contrary, each student had opportunities to participate in the group mind mapping activity in the 1:1 shared-display approach. Moreover, these 1:1 computers enabled them to browse files according to their own reading pace. Such results indicate that collaborative web exploration activities require not only a shared computer but also 1:1 computers by which students can take part in the group activity.
Table 2. The mind mapping activities in two approaches

<table>
<thead>
<tr>
<th>Approach</th>
<th>Shared-computer</th>
<th>1:1 shared-display</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group</td>
<td>G1</td>
<td>G2</td>
</tr>
<tr>
<td>Numbers of added concept nodes</td>
<td>12</td>
<td>14</td>
</tr>
<tr>
<td>Numbers of deleted concept nodes</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>Numbers of added comment nodes</td>
<td>6</td>
<td>14</td>
</tr>
<tr>
<td>Numbers of deleted comment nodes</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Frequency of created linking</td>
<td>16</td>
<td>23</td>
</tr>
<tr>
<td>Frequency of deleted linking</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>Numbers of uploaded papers</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>Numbers of deleted papers</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Numbers of browsing paper</td>
<td>8</td>
<td>5</td>
</tr>
<tr>
<td>Total</td>
<td>55</td>
<td>59</td>
</tr>
</tbody>
</table>

Interaction pattern

All the dialogue threads were classified into categories based on the content of the dialogues. This study found a total 11 categories of dialogue threads. Table 3 shows that the categories and some examples of the dialogue threads.

Table 3. Threads categorization

<table>
<thead>
<tr>
<th>Threads</th>
<th>Purpose</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Procedure discussion</td>
<td>Members discuss the process of their exploration activity.</td>
<td>A: I think we should search for related information first.</td>
</tr>
<tr>
<td>Direction</td>
<td>Members negotiate what and how to find information.</td>
<td>A: I think we should search for information about groupware for collaboration.</td>
</tr>
<tr>
<td>Information judgment</td>
<td>Members judge the value of the information searching process.</td>
<td>A: I think your idea is out-of-date.</td>
</tr>
<tr>
<td>Information organization</td>
<td>Members discuss how to organize information with groupware.</td>
<td>A: Can we use the term “network groupware” instead of simple “groupware”?</td>
</tr>
<tr>
<td></td>
<td></td>
<td>B: Groupware is not necessarily networked!</td>
</tr>
<tr>
<td>Self-explanation</td>
<td>Members take a self-explanation strategy to clarify information they found.</td>
<td>A: What is synchronous and asynchronous?</td>
</tr>
<tr>
<td>Clarification</td>
<td>Members clarify the content of information they found to their peers.</td>
<td>A: What is the main idea of this paper?</td>
</tr>
<tr>
<td></td>
<td></td>
<td>B: It focused on the experiment comparison.</td>
</tr>
<tr>
<td>Group decision</td>
<td>Members negotiate to make decision.</td>
<td>A: Should we add this issue?</td>
</tr>
<tr>
<td>Status probe</td>
<td>Members report their working status to others.</td>
<td>A: Did you read this paper?</td>
</tr>
<tr>
<td></td>
<td></td>
<td>B: Yes, I did.</td>
</tr>
<tr>
<td>Technological problem</td>
<td>The problem related to the technological environment.</td>
<td>A: What’s wrong with the computer?</td>
</tr>
<tr>
<td>Action request</td>
<td>Members ask others to perform work.</td>
<td>A: Please scroll down the screen. There should be a figure.</td>
</tr>
<tr>
<td>Informal conversation</td>
<td>The dialogues were irrelevant to the learning task.</td>
<td>A: Your wireless mouse is fancy.</td>
</tr>
</tbody>
</table>

Table 4 shows frequency and percentages of the 11 categories of the dialogue threads in the two approaches. The total number of dialogue threads of the three groups in the shared-computer approach is 992 which is much higher than 746 that they demonstrated in the 1:1 shared-display approach. This may be because the students spent more time on individual exploration activities. Table 4 also demonstrated that the students often requested their peers to take certain actions on the shared computers in the shared-computer approach. This may be because they lacked individual learning device. Such action requests were less frequent in the 1:1 shared-display approach. Conversely, they demonstrated higher percentage of procedure discussion because they had to integrate their individual exploration results into the group activity. Such result is consisted with the onscreen video indicating that the students first took part in individual exploration and then joined the group activity based on their individual
exploration. However, in the 1:1 shared-display approach, they encountered a more complex technological setting. Hence, they often discussed with other members to resolve the technological problems.

<table>
<thead>
<tr>
<th>Approach</th>
<th>Shared-computer</th>
<th>1:1 shared-display</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group</td>
<td>G1</td>
<td>G2</td>
</tr>
<tr>
<td>Procedure discussion</td>
<td>33(9%)</td>
<td>13(3%)</td>
</tr>
<tr>
<td>Direction</td>
<td>21(6%)</td>
<td>23(6%)</td>
</tr>
<tr>
<td>Information judgment</td>
<td>33(9%)</td>
<td>71(17%)</td>
</tr>
<tr>
<td>Information organization</td>
<td>32(9%)</td>
<td>42(10%)</td>
</tr>
<tr>
<td>Self-explanation</td>
<td>53(15%)</td>
<td>94(23%)</td>
</tr>
<tr>
<td>Clarification</td>
<td>28(8%)</td>
<td>73(18%)</td>
</tr>
<tr>
<td>Group decision</td>
<td>8(2%)</td>
<td>4(1%)</td>
</tr>
<tr>
<td>Status probe</td>
<td>32(9%)</td>
<td>13(3%)</td>
</tr>
<tr>
<td>Technological problem</td>
<td>12(3%)</td>
<td>10(2%)</td>
</tr>
<tr>
<td>Action request</td>
<td>60(17%)</td>
<td>47(11%)</td>
</tr>
<tr>
<td>Informal conversation</td>
<td>36(10%)</td>
<td>25(6%)</td>
</tr>
<tr>
<td>Total</td>
<td>348(100%)</td>
<td>415(100%)</td>
</tr>
</tbody>
</table>

The interaction patterns in the two approaches were schematized in Figure 4 and Figure 5. It should be noted that the technological problem, action request, and informal conversation threads were excluded in the interaction pattern analysis because these threads are not the core activities during collaborative web exploration activities. Moreover, this study only displays the major transitions among the dialogue threads by ignoring the transition with small probability. More specifically, the transition probabilities were compared with the random transition probability under uniform distribution (1/8) by Chi-square because there were eight major dialogue threads. Only the transitions which demonstrated significantly higher probability than the random transition did under the uniform distribution were displayed in the transition diagram.

Figure 4 and Figure 5 illustrate that the students exhibited different interaction patterns in the two approaches. The interaction patterns show that the students often took a self-explanation and clarification strategies together during their discussion (Clarification -> Self-explanation and Self-explanation -> Clarification) in the shared computer approach. Based on such discussions, they further discussed how to organize the information they founded (Clarification -> Information organization). However, the results of these discussions were not used in the discussion of information judgment and group decision because there is not a major transition between these dialogue threads. In other words, the discussion becomes fragmented because the dialogue threads did not coherently facilitate the group to judge information and make group decision.

Figure 4. The interaction pattern in the shared-computer approach
On the contrary, the students in the 1:1 shared-display approach demonstrated a different interaction pattern. In such a pattern, the students’ self-explanation did not only connect to the clarification of information (self-explanation -> clarification), but also to the judgment of information (self-explanation -> information judgment). Meanwhile, the discussion of information judgment also connected to the clarification of information (information judgment -> clarification) and helped the group to make decision (information judgment -> group decision). However, when they were judging the value of information, they often needed to probe the status of their peers because each student was using their own 1:1 computers (information judgment -> status probe). Compared to the shared-computer approach, the students demonstrated a more elaborative discussion patterns in which the students clarified and self-reflect upon the information to judge the value of information and make group decision.

Conclusion and Implication

Educators and researchers have emphasized the important of collaborative web exploration activities in educational context. The shared-computer approach was widely applied to facilitate students to explore on the web in a collaborative manner. However, such an approach may limit students’ active participation and impede group interaction. This study therefore proposed the 1:1 shared-display approach to facilitate such a collaborative learning activity. The results of this study show that 1:1 computers are necessary to support collaborative web exploration activity with shared displays as they could support the students to take part in individual exploration and join the group activity based on their individual exploration. When using the 1:1 computers with the shared display, the students discussed with each other in a more elaborative way than they did without such computers.

The analysis of this study found that the collaborative web exploration activities involved both group and individual activities. More specifically, the students firstly needed to conduct individual exploration and then joined group activity to discuss with other members. However, the students in the shared-computer approach rarely conduct individual activity due to the lack of 1:1 computers. The 1:1 shared-display approach could support both of individual and group activities as well as the rapid transition between the two activities. Researchers such as Jeong and Chi (1997) asserted that both the self-construction and co-construction are crucial to collaborative learning. Previous studies by Elwart-Keys et al. (1990) and Mandviwalla and Offman (1994) also asserted that students during collaborative learning need to transit between the self-construction and co-construction activities. The findings of this study supports that lack of individual devices may limit the self-exploration activities during the collaborative learning. Educators may find both shared displays and 1:1 individual devices are necessary to implement an effective collaborative learning activity.

The study by Liu and Kao (2007), Amershi and Morris (2008) and Lee (2010) found that the shared displays are necessary to increase the activity awareness as they can become the shared focus among different students. One further research question following these studies is what benefits the 1:1 computers can afford in the shared-display
setting. The analysis of this study found that the students in the 1:1 shared-display approach demonstrated more frequently exploratory activities on the mind map than they did in the shared-computer. In other words, the students with the 1:1 computers demonstrated more active participation in both individual and group learning activities in a way that can accommodate each individual’s reading pace. Such results echo the assentation of Soloway and Norris (2001) indicating devices “at hands” are a critical condition to facilitate active technology-enhance learning activities as students do not need to spend extra efforts on accessing the learning devices and sharing the learning devices with others. Recently, more and more shared displays are now available in public areas such as libraries. There is a need to provide some facilities to help students to orchestrate the 1:1 computers with the shared displays. By doing so, the shared displays can better support collaborative learning by engaging all students to participate in the collaborative activity.

Previous studies by Liu and Tsai (2008) has identified several interaction patterns, such as distributed and centralized interaction patterns, during collaborative discussion in terms of the question-response relationships between students. The study by Lee (2010) further analyzed the interaction patterns based on the availability of shared displays. The results of his study confirmed that the shared displays may influence the interaction patterns in terms of verbal and non-verbal interactions. These literatures indicated that both the question-response relationship and non-verbal interaction records are helpful to uncover the interaction patterns during collaborative learning. However, this study analyzed the interaction patterns based on the functional objectives of dialogues. In other words, student dialogues were categorized based on their functions and dialogues were analyzed based on the sequence relationships between these functional dialogues. The results of this study found that the students demonstrated a more elaborate discussion patterns when they explored with 1:1 computers than they did without the computers. Such a finding supports that such a method is helpful to understand how discussion progressed to achieve the group goal and the quality of discussion. Researchers may find it helpful to investigate interaction patterns during collaborative learning in other collaborative contexts.

The result of the study exhibited the benefits of the 1:1 computers in the collaborative web activities. However, the participants of this study were graduate students and most of the participants were male. In addition, they were from the course ‘The theory and practice of mobile learning’. They might hold more positive perceptions toward the use of one-to-one computers in learning. Therefore, the findings of this study may not be over-generalized to students of different levels or different student groups. In addition, this study investigated the exploratory activities and interaction pattern as students are using laptop computers with shared-displays. It would be interesting to investigate how students learn collaboratively with different 1:1 computers, such as iPads or smart phones together with the shared-displays. Moreover, the findings of this study were obtained from system logs, onscreen and activity videos. It will be worthwhile to investigate how the two technological environments may influence students’ perceptions of collaborative learning. For instance, questionnaires may be used to obtain students’ perception of the collaborative activity. Gathering answers of these issues may be helpful to gain a better understanding of the role of 1:1 computers and shared displays in supporting collaborative learning.

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References


Curriculum-guided Crowd Sourcing of Assessments in a Developing Country

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ABSTRACT

Success of Wikipedia has opened a number of possibilities for crowd sourcing learning resources. However, not all crowd sourcing initiatives are successful. For developing countries, adoption factors like lack of infrastructure and poor teacher training can have an impact on success of such systems. This paper presents an exploratory study to determine if teachers in a developing country are able to create quality multiple-choice questions for primary school students. An adoption model is developed and evaluated to ascertain if the teachers would actually contribute to such a Wiki. Results are that, given student learning outcomes, content constraints, and a Bloom’s assessment level, a reasonable number of teachers were able to formulate quality questions, and that there is a strong intention to use such a system. Teachers with high intention to adopt also had a better attitude, enjoyed making questions and found the process easy to use. However, there is no obvious relationship between the intention to use and an ability to pose good assessments. In addition, there is no obvious predictor of where the good question contributors came from.

Keywords

Crowd sourcing, Wiki, Developing world, Primary education, Online assessments

Introduction

According to UNESCO, 67 of the 142 countries surveyed had a moderate to severe primary teacher gap, and the countries with gaps were primarily developing countries (The Global Demand for Primary teachers – 2010 Update. Information Sheet no. 5, 2010). Enabling educational technologies can help obviate this teacher gap. For example, given the success of Wikipedia, it is tempting to consider a crowd sourcing platform that provides automated assessment support for primary school teachers. Crowd sourcing is not new to the developing world and platforms like Ushahidi have been successfully used in developing countries for citizen journalism (Heinzelman & Waters, 2010). Similarly, in Nigeria, Wiki has been used in very large classes (> 2000 students) with a positive impact (Aborisade, 2009). Unfortunately, not all crowd sourcing experiments are as successful as Wikipedia. For example, a recent study showed that only a small percentage of Wikis exhibited healthy growth (Kittur & Kraut 2010). Culture is another important variable. For example, using various measures of cultural influences, Pfeil, Zaphiris, & Ang (2006) found differences in patterns of Wiki contributor’s behaviour across cultures. A study of teachers using Wiki shows that teachers were frustrated by their own materials being modified by others, and were afraid of criticism from others (Lio, Fraboni, & Leo, 2005). In addition, teachers were reluctant in giving up ownership of materials and had a fear that they may break the whole system by their changes. Lio et al. (2005) also observed that teachers were hesitant in changing others’ work for fear of offending, and were somewhat put off by the open-ended nature of the Wiki; the fact that the materials they created would keep changing.

Another pertinent observation is that a crowd sourcing model entirely driven by interests of the contributors does not necessarily guarantee adequate curriculum coverage for formal learning scenarios. For example, Halavais & Lackaff (2008) and Zhang, Sun, Datta, Chang & Lim (2010) show that topical coverage in crowd sourced systems like Wikipedia, is different than that of expert-created representations. Another related phenomenon is the “long tail” behaviour of users of Wikipedia (Riedl, 2009); a small number of topics on Wikipedia are visited most often. This small proportion of topics also has higher quality as well (Wilkinson & Huberman, 2007). Taken together, the implication is that without adequate guidance from a curriculum, a crowd sourced Wiki may have skewed coverage in terms of content and quality. Therefore, a crowd sourcing solution for assessments must explicitly incorporate the curriculum. This creates an essential tension between “democratic” spirit of crowd sourcing and the curricular needs of a particular community. Any realistic deployment of a crowd sourcing solution to learning in general must negotiate this tension successfully.
This paper presents an exploratory study to determine if a curriculum-guided crowd sourcing system for assessments would work in the developing world context. The context of the study is presented first. Design of the study based on models of adoption, quality of assessments, and problem posing, is presented next. This is followed by a description of the implementation and results. A discussion follows, and the paper ends with a conclusion.

The Context

This section describes the context of the study presented in this paper; schools, teachers, the national curriculum and textbooks. Each is discussed below.

Country, Schools Systems and Teachers

One key to the success of a crowd sourcing system is the availability and diversity of a large number of potential contributors. The developing country chosen for this study was Pakistan which has 214,650 schools, 1,190,925 teachers and a student base of 26 million plus (Pakistan education statistics 2008-09, 2009).

Many schools in Pakistan typically do not have adequate infrastructural support like access to electricity, computers or the Internet. Therefore, an assessment Wiki needs to ensure that alternative mechanism like the mobile phones or physical mail is available for contributors and users. Other developing countries have similar constraints. For example, Internet is prohibitively expensive in many developing countries (Negash, 2010) and Internet penetration is also low (The World in 2010 - ICT Facts and Figures, 2010). According to UNESCO, 56.8% of students across the WEI developing countries had no access to computers at all, and in India, 85% of the schools participating in the study did not have any computers (Grisay, 2008).

Another important aspect of crowd sourcing is the quality of potential contributors. According to the World Bank, 85% of the primary teachers in Pakistan receive some type of pre-service or in-service teacher training (Trained Teachers in Primary Education, 2012). However, there is considerable variability in the educational background of teachers who can hold a PCT (10+1 years), CT (12+1 years), B.Ed (14+1 years), Bsc.Ed (12+3 years), or an M.Ed degree. While little data is available for teachers in the private sector, 42% of public school teachers in Pakistan have a CT degree while only 9.76% hold an M.Ed degree (Pakistan Education Statistics 2008-09, 2009). Hence, while a small pool (<10%) of highly qualified teachers is potentially available for crowd sourcing, the majority of teachers in Pakistan come from lesser educational qualifications.

Figure 1. Teachers in Pakistan work and come from a variety of backgrounds
In summary, a large base of school teachers as potential contributors to an assessment Wiki is available in Pakistan. However, most of these teachers are not well-trained, have varying educational backgrounds and work in environments with varying infrastructural support.

The National Curriculum

As mentioned earlier, the “long-tail” behaviour of crowd-sourcing systems is well-recognized where the topics that evolve, and their quality, typically depend on the interests of a small set of contributors. Therefore, an explicit inclusion of the curriculum is necessary to avoid “black holes” in the assessment Wiki where assessments do not exist, or are of a lesser quality. Therefore, one pre-condition for a “balanced” assessment Wiki is the availability of an agreed upon formal curriculum which can be used as a guide by assessment contributors. Figure 2 shows Pakistan’s national curriculum for Science (The National Curriculum of Pakistan, 2006).

![Figure 2. The Science Curriculum of Pakistan and its components](image)

Each learning strand is segmented into key stage outcomes or benchmarks. Benchmarks are based on student learning outcomes (SLO). Student learning outcomes, in turn, are organized into learning units where each learning unit consists of a list of learning outcomes and associated “content” which indicates topics to be covered in achieving the learning outcomes. Finally, learning units are grouped for each Grade level.

Textbooks

Textbooks provide an important context for a teacher and students, and any assessment crowd sourcing solution will eventually have to map assessments to one or more sections or units in a textbook. Despite the fact that the national curriculum provides clear guidelines for preparing a textbook, different textbook authors have taken radically different approaches. For example, one textbook (Ahmed, Rasheed, Ali, & Nooruddin, 2010) is based primarily on an activity-based pedagogy; the learning design consists of an activity followed by a set of questions and then explanations. Another textbook (Darsi Science Book for Grade 4, 2004), takes a more conventional approach, and lays out the learning outcomes of each unit followed by a description with examples, and ending with a summary of what was learned. A third textbook (Elementary Science for Class 4, 2010) takes an intermediate approach to learning design; each unit starts with a description, followed by an activity and corresponding questions.
The diversity of textbooks and the various approaches suggests, that in addition to the national curriculum, the crowd sourcing system must incorporate explicit links to the various prevalent textbooks to help teachers select the relevant questions to pose or use.

**Study Design**

**Objectives**

This study had two objectives. First objective was to determine if teachers in a developing country like Pakistan are able to crowd source high quality multiple-choice questions for SLOs in the national curriculum. In a typical scenario, a teacher would be asked to provide curriculum constrained structured input to the Wiki in the form of a multiple-choice question. The second objective of the study was to determine the extent to which these teachers were likely to adopt such a crowd sourcing system. The key question here was teachers’ willingness to contribute assessments for such a system.

**Models**

In order to answer the two questions posed in this study, three models were formulated as described below.

*Quality Model*

Assessing the quality of posed questions in a non-trivial problem. For example, (Tongchuay & Praneetpolgrang, 2008) identified 22 different factors to measure the quality of knowledge. To answer the first objective which dealt with the quality of assessments, a simplified model of quality for assessments were derived from (Zualkernan, 2009). The model is shown in Figure 3. Each of the five quality factors in the model is explained with the help of a problem posing example next. For example, assume that the teacher is given a task to pose a multiple-choice question for the following SLO and the associated Content.

**SLO:** Identify the sources of common foods  
**Content:** Sources of different food group (fruits, vegetables, meat, pulses and cereals)

Based on this input, assume that a teacher creates the following multiple-choice question.

1. Carbohydrates
2. Proteins (correct answer)
3. Minerals
4. Vitamins

**Correctness** quality factor ensures that an assessment is correct in assessing a particular SLO. This question posed in the example above is correct in satisfying the SLO, not only because it is factually correct, but also because the question is consistent with the verb “Identify” in having the student recall a relationship.

Traditionally, **Reliability** is defined in terms of failure rates (McCall, Richards, and Walters, 1977). Therefore, failure rate of an assessment is its inability to discover a gap in the understanding of a student with respect to a particular SLO. For example, how many students guessed the correct answer without a complete understanding? Alternatively, how many students generally satisfied the learning outcome, but the posed question was so esoteric that they got it wrong. The example question is a bit ambiguous in that both Meat and Pulses also contain B-Vitamins, and therefore, a more “reliable” question would have had the stem “Meats and Pulses are primary sources of.”

**Efficiency** is concerned with optimizing resources to deliver assessments. In other words, how much of the learning outcome can be assessed by a single question. For example, the posed question tries to be efficient by asking the student to judge two foods (Meats and Pulses) in the same question. This is much more efficient than asking for the source of only one food, for example.
Usability deals with how easy it is to use the assessment from a student’s perspective. The example question above is easy to use because it is short, and asks a student to select (tick) only one answer; questions with “select all that apply” types of choices are much less usable.

Verifiability deals with how easy it is to judge the correctness of a question. For example, it is straightforward to verify correctness of the answer in the example question; more complicated questions may require a reviewer to consult reference materials, or to do calculations.

**Figure 3. The quality model to assess the quality of multiple-choice questions**

**Problem Posing Model**

When a teacher is asked to formulate a multiple-choice question for a SLO and associated content, they are in fact posing a problem. Problem posing has been studied extensively in Mathematics education (English, 1996; Principles and standards for school mathematics, 2000; Perrin, 2009). There is a strong correlation between problem posing and problem solving (Silver & Cai, 1996; Kara, Özdemir, Sabri, & Albayraka, 2010; Lavva & Shrikib, 2010), and problem posing has been used as an assessment tool (Mestre, 2002). Further, systems that provide automatic feedback on the quality of posed problems (Hirashima, Yokoyama, Okamoto, & Takeuchi, 2007), and support collaborative problem posing have been implemented (Lin, 2010). Finally, various strategies for problem posing in Mathematics (Stoyanova, 2005) and process models of the problem posing process have also been developed (Christou, Mousoulides, Pittalis, Pitta-Pantazi, & Sriraman, 2005).

**Figure 4. The problem posing model for teachers**
This study uses the theoretical framework provided in (Zualkernan, 2011). According to this framework, as Figure 4 shows, in a Wiki problem posing task, goal of the teacher was to formulate a multiple-choice question which was congruent with a student learning outcome derived from the national curriculum. Teacher was successful if the question measured the “fit” required for a Grade IV student in an appropriate manner. This “fit” was judged by the quality model presented earlier. In this study, the teacher was provided with the student learning outcomes and the associated learning content for Grade IV. No assumptions were made regarding teachers’ cognitive constraints, traits or states. It is typically assumed that problem posing gets harder moving up the Bloom’s Taxonomy (Bloom, 1956); Analysis problem are typically more difficult to pose than Knowledge questions, for example. Therefore, one parameter of the Adaptation of the teacher was how well they are able to formulate questions related to the various levels of Bloom’s Taxonomy.

This research employed a version of the Bloom’s model used to train teachers (Marzano & Kendall, 2007). As Table 1 shows, in this model various action verbs are proposed to provide teachers with hints about how to create questions at a particular level of comprehension.

<table>
<thead>
<tr>
<th>Action Verb</th>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recognize (from a list), Select from (a list), Identify (from a list), Determine (if the following are true), etc.</td>
<td>Retrieval</td>
<td>Can a student recognize or recall information or follow a process.</td>
</tr>
<tr>
<td>Describe how or why, Describe the key points of, Describe the effects, etc.</td>
<td>Comprehension</td>
<td>Can a student integrate or symbolize what they have learned about a concept, process, procedure etc.</td>
</tr>
<tr>
<td>Categorize, Compare and contrast, Differentiate, Discriminate, Distinguish, etc.</td>
<td>Analysis</td>
<td>Can a student compare, classify, generalize and compare errors</td>
</tr>
<tr>
<td>Decide, Select the best among the following alternatives, etc.</td>
<td>Knowledge</td>
<td>Utilization</td>
</tr>
</tbody>
</table>

**Adoption Model**

In addition to the quality of posed assessments, one key to the success of an assessment Wiki is the willingness of teachers to adopt the system by sharing their assessment knowledge. This study uses the Technology Adoption Model (TAM) (Davis, Bagozzi & Warshaw, 1989; Venkatesh & Davis 2000; Wang, Lin, Chen, & Yang, 2008) for this purpose. This adoption model is designed to focus mostly on the individual and does not include wider aspects of adoption like e-learning readiness (Hammadi, Ahmed & Zualkernan, 2010), or developing country related factors like quality of physical infrastructure, societal norms etc. (Woolf, Arroyo, & Zualkernan, 2011). The additional factor of *Enjoyment* (Davis, Bagozzi & Warshaw, 1992) was also explicitly incorporated into the model.

![Figure 5. An adoption model for crowd-sourcing of assessments](image)
As Figure 5 shows, the adoption model consists of five key factors. The most important factor is the Perceived Intention of Use which is a determination of whether the teachers intend to use such a system. This factor, in turn, can be influenced by four other factors like Perceived Usefulness, etc. Each factor looks at a different dimension. For example, Perceived Enjoyment determines if the teachers enjoyed formulating multiple-choice questions for crowd sourcing. The various questions to assess each of the factors are shown in Table 2. The “process” in Table 2 refers to the process of teachers being given Table 2, followed by multiple question posing tasks where they are asked to pose a multiple choice question for a pair of SLO and associated content.

<table>
<thead>
<tr>
<th>Factor</th>
<th>Item</th>
<th>Statement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Usefulness</td>
<td>U1</td>
<td>Using this process will improve my ability to write assessments</td>
</tr>
<tr>
<td></td>
<td>U2</td>
<td>This process will help me write assessments more quickly</td>
</tr>
<tr>
<td></td>
<td>U3</td>
<td>This process will increase my productivity of writing assessments</td>
</tr>
<tr>
<td></td>
<td>U4</td>
<td>Using this process will enhance my effectiveness as a teacher</td>
</tr>
<tr>
<td>Ease of Use</td>
<td>E1</td>
<td>The process was easy to follow</td>
</tr>
<tr>
<td></td>
<td>E2</td>
<td>The process was easy to learn</td>
</tr>
<tr>
<td></td>
<td>E3</td>
<td>Overall, I found the process to be straightforward</td>
</tr>
<tr>
<td>Enjoyment</td>
<td>EN1</td>
<td>I liked using the process to create assessments</td>
</tr>
<tr>
<td></td>
<td>EN2</td>
<td>The experience of using this process was enjoyable</td>
</tr>
<tr>
<td></td>
<td>EN3</td>
<td>I had fun using the process</td>
</tr>
<tr>
<td>Intention to adopt</td>
<td>INT1</td>
<td>I think I will use this process in the future</td>
</tr>
<tr>
<td></td>
<td>INT2</td>
<td>I think that this process is a worthwhile tool for creating assessments</td>
</tr>
<tr>
<td>Attitude toward use</td>
<td>AT1</td>
<td>I like to build assessments using structured processes like this one</td>
</tr>
<tr>
<td></td>
<td>AT2</td>
<td>I feel good about using this structured process approach to create assessments</td>
</tr>
<tr>
<td></td>
<td>AT3</td>
<td>Overall, I like this approach to creating assessments</td>
</tr>
</tbody>
</table>

**The Task**

Grade IV Science and English were chosen as the two target subject areas. As described earlier, based on the problem posing model, each teacher was provided with an SLO paired with content, and was asked to pose a multiple-choice question that measured the student learning outcomes at the correct level (see Table 1). For example, for Science, a student learning outcome of “Identify sources of common food” was one learning outcome paired with “Sources of different food groups (fruits, vegetables, meat, pulses, and cereals)” as the associated content. Since this SLO is using the verb “Identify,” an appropriate question should be at the Retrieval level (Table 1). Each teacher was provided with four SLOs and the associated content taken verbatim from the national curriculum of Pakistan, and asked to formulate one multiple-choice question for each SLO. To help teachers along, an expanded form of Table 1 was also provided to each teacher with a brief explanation of how to use the table to pose questions.

**Data Collection and Coding**

The teachers filled-out an anonymous pre- and post- task survey. The pre-task survey asked for basic information like gender, years of experience etc. The post-task survey was based on the adoption model and asked the teachers to rate various measures for each of the five adoption factors explained in the adoption model presented earlier on a Lickert Scale from 1 (Strongly Agree) to 5 (Strongly Disagree). The model was internally consistent with Cohen’s kappa values of at least 0.7 for each factor.

After data from the teachers was collected, two judges each was asked to rate the quality of each question using the quality model shown earlier. Each judge rated each quality dimension (e.g., Correctness) on a Lickert Scale from 1 (Strongly Agree) to 5 (Strongly Disagree). Each judge had an M.Ed degree and at least 15 years of teaching experience in the relevant subject. The inter-judge reliability using Cohen’s kappa was more than 0.7 in all cases and hence appropriate.
Implementation

The experiment was carried out in Pakistan in December, 2010 with the help of volunteers. Thirty six Grade IV teachers participated with 4 teachers from teacher training-affiliated schools, 9 from private urban schools, 8 from rural private schools, 4 from urban government schools, 6 from rural government schools and 5 from schools run by non-profit organizations. 25 (69%) of the 36 teachers were female. 17 (47%) were English teachers while the rest taught Science (53%). The average teacher age was 31.02 years (SD=5.73) and teachers had a mean teaching experience of 7.47 years (SD=4.8). 26 teachers had participated in some sort of specialized teacher training program. Location wise, 22 teachers were based in Karachi, 8 in Peshawar and 6 in Nowshera; Karachi is about a thousand miles away from Peshawar and Nowshera that are co-located.

Results

Quality of posed questions

In order to determine an overall quality measure for each teacher, an arithmetic average of the ratings for all four questions posed by each teacher was used as the criteria for total quality. Non-parametric analysis was used because this variable called Total-Quality was not normally distributed (Anderson-Darlington, p<0.05). The median for Total-Quality was 2.354 with estimated 95% confidence intervals of (2.02, 2.7) (Wilcoxon-Signed Rank Test) on a scale of 1 (Strongly Agree) to 5 (Strongly Disagree). In other words, the overall quality of all the questions was judged to be somewhat mediocre. However, the top quartile (top 25%) of the teachers had the median Total-Quality of 1.104 (Strongly Agree) with a 95% confidence interval of (1.000, 1.167) suggesting that they could create excellent questions. In order to determine what was impacting the quality of questions, several tests were carried out as explained below.

Type of school had an impact on the quality of questions posed (Levene Statistic =0.53; p = 0.749: Kruskul-Wallis; H= 13.50; DF=5; P=0.019). Median rank of teachers from urban and rural Government schools (6.5 and 10.5 respectively) was significantly better than the other schools (the average rank being 18.5).

Location of teachers had an impact on the quality of questions posed as well (Levene Statistic =1.6; p = 0.217: Kruskul-Wallis; H=16.86; DF=2; P=0.000). The median rank of Peshawar and Nowshera (7.8 and 12 respectively) teachers was significantly better than teachers from Karachi (the average rank being 18.5).

Surprisingly, prior teacher training whether it was short courses, workshops or educational degrees, did not have an impact on the quality of questions posed (Levene Statistic =0.04; p=0.839: Kruskul-Wallis; H=2.81, DF =1, P = 0.093). The median rank of those with teacher training (Median rank = 16.7) was better than those with no teacher training (Median rank = 23.3) but not statistically significant at p<0.05.

As expected, the Subject did have an impact on quality of questions posed (Levene Statistic =0.47; p = 0.497: Kruskul-Wallis; H = 4.57, DF = 1, P = 0.032). The Science teachers came up with higher quality questions (median rank of 14.9) than English teachers (median rank of 22.9).

The teachers were divided into the four age categories of less than 25 years, 26-30 years 31-35 years and 36 to 40 years old. Based on these categories, no difference was detected in the quality of questions based on age (Levene Statistic =0.38; p = 0.77: Kruskul-Wallis; H = 1.79, DF = 3, P = 0.617). The youngest teachers had the lowest median rank (15.5) but the difference was not statistically significant.

Like age, the number of years of teaching experience (<5 years, 5-10 years, 11-15 years, 16+ years) did not seem to have an impact on the quality of questions (Levene Statistic =1.61; p = 0.205: Kruskul-Wallis; H = 3.72, DF = 3, P = 0.294). The teachers with more than 16 years of experience had the lowest median rank (9.5) but the difference was not statistically significant.

Finally, the effects of gender (Levene Statistic: 5.41, p= 0.026) or educational degree (Levene Statistic: 3.9, p= 0.030) could not be determined because the variances were not equal.
Adoption

Factors of Adoption

An arithmetic average of multiple measures was used for each of the five factors. Since neither of the five factors were normally distributed (Anderson-Darlington, p<0.05), Wilcoxon-Signed Rank with 95% estimated confidence intervals showed that all factors had a median of about 2 (Agree) on a scale of 1 (Strongly Agree) to 5 (Strongly Disagree) (U: Median = 2 (1.75,2.3), E: Median: 2.5 (2.167, 2.833), EN: Median=2.167 (1.833,2.667), AT: Median = 2 (1.833,2.333) and INT: Median=2 (1.750,2.250)). This means that, in general, the teachers were willing to adopt the process of creating multiple-choice questions.

No difference was detected between U and EN (Levene Statistics = 0.70, p= 0.288; Mann-Whitney W= 1286.5, p = 0.76), U and INT (Levene Statistics 0.37, p = 0.543; Mann-Whitney W=1351, p=0.6737), U and AT (Levene Statistic = 0.12, p= 0.733; Mann-Whitney W =1291, p=0.7989) E and EN (Levene Statistic=1.56,p=0.216; Mann-Whitney W=1366.5;p= 0.5548), E and INT (Levene Statistic=2.82, p=0.098; Mann-Whitney W=1442.0,p=0.1847), EN and INT (Levene Statistic=0.14,p=0.711; Mann-Whitney W =1389, p=0.3972), EN and AT (Levene Statistic=1.81,p=0.183; Mann-Whitney Mann-Whitney =1340, p=0.7719), INT and AT (Levene Statistic= 0.92, p=0.341; Mann-Whitney W=1261,p=0.5542 ). U and E (Levene Statistic = 5.97, p= 0.017) and E and AT (Levene Statistic= 8.54, p= 0.005) could not be compared because the variances were not the same.

In summary, the results generally suggest that all the adoption factors came from similar distributions. In other words, it is difficult to say if these teachers favored one adoption factor over another. For example, they did not think that the process was easier to use than being useful or less enjoyable.

Intention to Adopt

Intention to adopt (INT) is an important factor that directly determines if the teachers are inclined to adopt this process. Teachers were divided into four quartiles (lowest to highest 25%) based on their intention to adopt and any differences between how they viewed the other adoption factors were determined as shown below.

There was no difference between teachers from different quartiles of intention to adopt in terms of their rating of Usefulness of the process (Levene Statistic=0.95, p= 0.427; Kruskal-Wallis H = 716, DF = 3, P = 0.067)

There was a difference between the teachers who had a high intention to use with respect to the Ease of Use factor (Levene: 1.88, p=.152; Kruskal-Wallis H =19.14, DF = 3, P = 0.000). The teachers with high intention to adopt had a median Ease of Use rank of 9.5 which was higher than the teachers in lower-percentiles.

There was a difference with respect to Enjoyment (Levene Statistic=1.81, p=.64; Kruskal-Wallis H = 22.38, DF = 3, P = 0.000). The teachers with high intention to adopt had a median Enjoyment rank of 9.9 which was higher than those in lower-percentiles.

There was a difference (Levene: 0.5, p= .687; Kruskal-Wallis H = 13.12, DF =3, P=0.004). The teachers with high intention to adopt had a median Attitude rank of 12.2 which was higher than the lower-percentiles.

In summary, the teachers in the high percentile of intention to adopt behaved differently with respect to three of the other four adoption factors. These teachers typically also rated most other adoption factors higher.

Relationship between quality and intention to adopt

One key question was whether there was any obvious relationship between the quality of questions created by teachers and their intention to adopt. The teachers were divided into four categories based on quartiles of quality of their questions. There was no significant difference between teachers in the various quartiles with respect to their rating of the five adoption variables (U (Levene Statistic=1.37,p=0.302; Kruskal-Wallis H = 1.01, DF = 3, P = 0.800), E(Levene Statistic=1.23, 0.314; Kruskal-Wallis H = 3.68, DF = 3, P = 0.298), EN(Levene Statistic=0.64,
0.594; Kruskal-Wallis, H = 0.74, DF = 3, P = 0.865), INT(Levene Statistic=0.54, p=0.657; Kruskal-Wallis H = 1.21, DF = 3, P = 0.751), AT(Levene Statistic=1.27, p=0.302; Kruskal-Wallis H = 2.30, DF = 3, P = 0.512). This means that there was no obvious relationship between adoption variables across the various classes of teachers with respect to quality of posed questions. There was no difference in intention to adopt even for teachers in the top quartile 25% with respect to high quality questions (Levene Statistic=0.69, p=0.534; Kruskal-Wallis H=0.11, DF=2, P=0.948).

Limitations

The results are limited to the number of teachers, their distribution in the country, topics and type of questions posed. The study also used a very simple and limited adoption model based on TAM. Many expanded variants and especially the Unified Theory of Acceptance and Use of Technology (UTAUT) (Venkatesh et al., 2003) can be used for subsequent investigations. Table 3 presents an incomplete list of potential factors that have an impact on adoption of knowledge sharing (and withholding) in communities of practice. It is important to contextualize the adoption model because some factors like Reciprocity are particularly relevant for Wikis. Other factors like Self-efficacy, on the other hand, are important for adoption of educational Wikis (Liu, 2010) but have been de-emphasized in generic models like UTAUT.

<table>
<thead>
<tr>
<th>Table 3. Potential factors for inclusion in an expanded adoption model for assessment Wikis</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Factor</strong></td>
</tr>
<tr>
<td>Benevolence</td>
</tr>
<tr>
<td>Self-efficacy</td>
</tr>
<tr>
<td>Trust</td>
</tr>
<tr>
<td>Reciprocity</td>
</tr>
<tr>
<td>Fair reward</td>
</tr>
<tr>
<td>Enthusiasm and persistence</td>
</tr>
<tr>
<td>Empathy</td>
</tr>
<tr>
<td>Community identification</td>
</tr>
<tr>
<td>“Lead user” characteristics</td>
</tr>
<tr>
<td>Team characteristics (e.g., diversity),</td>
</tr>
<tr>
<td>Cultural characteristics (e.g., collectivism)</td>
</tr>
</tbody>
</table>

Discussion

Within experimental limits, the study shows that teachers in a developing country like Pakistan are able to formulate adequate multiple-choice questions tied to student learning outcomes without any specialized training. What is relevant to crowd sourcing is that the top quartile of these teachers was able to formulate excellent questions. However, it is interesting to note that teachers from seemingly backwards areas of the country like Nowshera and Peshawar, where the teacher training programs are also lacking, were able to contribute better questions than those from the urban center of Karachi. In addition, no relationship was found between a teacher’s willingness to adopt the assessment creation process and an ability to pose good questions. This data support one of the key strengths and the potential weakness of crowd sourcing; it is very difficult to predict where the best contributors will come from.

While teachers who formulated better questions came from public schools and smaller cities, teacher training seemed not to have had an impact on the quality of questions which is surprising and needs to be explored; are teachers being trained adequately in problem posing? One explanation of why public school teachers performed better may be the plethora of foreign funding agency teacher training programs (like USAID and DFID) that typically target government schools.

The teachers, who had the highest willingness to adopt assessment Wiki, also enjoyed the process, found the process easy to use, and had a positive attitude towards contributing assessments. Usefulness, however, was not a distinguishing factor. In other words, teachers who were willing to adopt crowd sourcing did not necessarily believe
that the particular way of using the SLO and content along with the Bloom’s level would actually increase their
ability, productivity or effectiveness in writing assessments. Further research is needed to explore why this was the
case and to improve the process. However, this result does not deter from the fact that most teachers showed a high
willingness to use such a system.

**Conclusion**

This paper has investigated whether primary teachers in a developing country are able and willing to contribute high
quality multiple-choice questions that are aligned with the national curriculum. The results show that teachers are
not only able to do so, but are willing to contribute. The next step in this research is to expand the generality of
findings by incorporating other subjects like Mathematics and to expand the scope to include a larger number of
teachers. In parallel, an effort is being undertaken to develop and launch an Assessment-Wiki based on established
e-Learning standards which will eventually cover the complete national curriculum for K-12.

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PEDALE – A Peer Education Diagnostic and Learning Environment

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ABSTRACT

The basis for individual students’ instructional support by teachers is an individual diagnosis of one’s learning advances and difficulties. Even though sophisticated diagnostic tools exist, it remains an open question how diagnosis and learning can be merged into a consistent pedagogical method to support both teachers and students with feedback about the learning process. Aspects like the usage of open format questions, social inter-dependencies and heterogeneity, group-forming processes and the teachers supervision issue are taken into account. We propose a model for integration of peer assessment functionality for learning into a computer-based Adaptive Diagnostic Learning Environment to solve central problems of classroom diagnostic assessment, adaptive learning and knowledge transfer between peers in a classroom environment. The research approach focused on math learning scenarios for evaluation, but is expected to be applicable for other educational content as well. In the following paragraphs we identify several problems in classroom scenarios to be addressed, describe the model of the underlying approach, show the implementation details and explain the evaluation setup.

Keywords

Learner-centered Diagnostic Assessment, Technology-enhanced Learning, Knowledge Sharing

Introduction

Effectively supporting secondary school students in the classroom with appropriate learning material is a difficult task for a teacher. Despite the limited time for each student, instruction needs a proper diagnosis of each individual student’s competencies and difficulties in order to make adequate didactic decisions for further instructional support.

Currently, tests used to assess students’ understanding of certain topics are primarily paper-based (Howell, 2003). The results are aggregated by the teacher and afterwards feedback is provided to the students. These tests and diagnostic surveys have mainly been developed and accurately proofed from a psychometric point of view (Leighton/Gierl, 2007; Bayrhuber et al., 2010). This means a very precise and narrow focus on valid measurement, but is incompatible with daily classroom instruction as their evaluation is too work-intensive for teachers and the tests stay isolated from the intended learning processes. Using software tools instead can support teachers in assessing the students’ performance faster. Additional support for test adaption helps bridging the gap from diagnosis to instructional support.

Envisioned is a digital learning environment that allows the management of diagnostic and educational content and instructional feedback with the help of peer assessment and thereby affords bridging the gap between diagnosis and learning.

Related work

E-Learning environments that can serve diagnostic purposes are in the scope of different research interests. Intelligent Tutoring Systems try to keep track of the student’s input and are predefined in a very elaborate way (Ritter et al., 2007). They are proved to be useful providing feedback in time of the problem solutions. In addition didactic research proved the advantages of methods like learning by teaching, collaborative learning and the benefits of social exchange for motivation (Gillies, 2004).
The impact of peer assessment has been studied earlier (Damon, 1984), highlighting the positive effects like raising interest for challenging tasks and fostering pro-social behavior. Beside a general interest of students in examining peer work (Stepanyan et al., 2009) better knowledge acquisition has been shown for computer-supported collaborative work as well (Mohammad et al., 2009). From the field of computer science the Social Network Analysis has carried out extensive research to investigate the phenomenon of knowledge sharing over weak ties between users not closely related (Petróczi et al., 2006; Granovetter, 1973; Fetter, 2009). Strangers are strong providers of help and knowledge without a directly expected reward (Constant et al., 1996).

Software Adaption to the progress of individual learners is especially investigated in the field of Serious Games for Learning (Bellotti et al., 2009; Tan et al., 2007) as this field combines the challenges of dynamic reactions to user behavior in the game as well as the learned skills. Therefore software maintains a player model to adapt to characteristics of decision behavior in games and updates the probabilities of learned skills in a learner model. These models’ states parameterize specific issues like next scenes, challenges and information displayed to users.

**Motivation – Technology-enhanced Diagnosis and Learning**

Using software for diagnosis and learning still faces some conceptual and technical challenges:

**Computer Diagnosis Problem**

Processing and interpreting free text answers, drawings and different solutions of open format questions is still a challenge for computer systems. Advances in text and language processing are made continuously, especially if the context can be narrowed to a specific field. Nonetheless, the matching of semantic meaning in a student’s reply to the desired answer remains as a research field. Thus diagnostic software tools widely use multiple-choice, gap text or sorting rather than open format test questions (Ritter et al., 2007). Unfortunately open format test questions are the most important ones for teachers from a diagnostic point of view as they reveal misconceptions or partial understanding of students (Prediger et al., 2008). We call this the Computer Diagnosis Problem.

**Individual Group Assessment Problem**

Diagnosis is usually conducted on an individual level. This prevents students from working collaboratively, sharing knowledge and giving hints. At the same time the benefits of group learning has been reported in many studies (Gillies, 2004; Klawe/Phillips, 1995). More precisely classroom research shows advantages for learning when feedback is given by peers as well rather than by teachers only (Gillies, 2004). Peer tutoring helps students to understand their misconceptions better, if they are explained by other students as they use the same language and share a common background for communication (Damon, 1984). We call the fact, that for individual diagnosis students need to be assessed individually, but for learning knowledge sharing in the peer group is favored the Individual Group Assessment Problem. It is desired to allow the knowledge sharing without risking precise individual students’ assessment.

**Peer Matching Problem**

When students have to choose their peers in the classroom for a group work they usually feel obliged to choose their friends or peers of a similar proficiency level in the subject (Cohen, 1994). Both lead to a suboptimal, homogeneous group formation concerning instead of heterogeneous groups for optimal knowledge exchange and learning outcome for every group member. In secondary schools with classes that usually contain around 30 students a teacher has not the time to establish an optimal grouping for group work in pairs or triples as this would mean an intensive preparation to mix the students with different proficiency levels. Additionally learning styles should be taken into account for peer matching as it influences the perceived suitability of the group members and learning effects. Unfortunately students “tend to be rebellious if they are forced to work in groups that are not of their own choosing” (Mitchell et al., 2012). We call the fact that a mix of proficiency level is desired and learning styles should be considered for optimal knowledge exchange, but actually friendship and similar proficiency levels are matched the Peer Matching Problem.
Diagnosis Adaption Problem

The main goal of diagnosis is to provide a standardized and comparable result of individuals (OECD, 1999). A student’s motivation for participation (i.e. using the tools provided) increases significantly, if the questions provided fit her individual skills and prevent situations of boredom or anxiety (Buchanan/Csikszentmihalyi, 1991). We call the fact that a suitable level of diagnostic task difficulty increases the motivation and performance of a student while diagnosis needs to be inter-individually comparable the Diagnosis Adaption Problem.

Teacher’s Supervision Problem

The peer learning scenario where each student has his own pace and different tasks while sharing knowledge through feedback to each other by means of a computer-based environment is much more dynamic than traditional classroom setups. In order to keep control of the guidance and support of the class as a whole and each individual student at once, the teacher needs to have a tool at hand to supervise and influence the scenario in order to give the individual instructional support and have a diagnostic overview. The requirements concerning the teacher supervision can be summarized as the Teacher’s Supervision Problem.

Scenario and Concept

We propose a system called PEDALE, as a novel approach addressing the above-mentioned problems by combining diagnosis and learning together with social networking principles for peer assessment and knowledge sharing between students. To the best of our knowledge no software with such an approach exists. In order to address the problems stated above, the system will use a carefully reviewed and empirically validated didactic model of competence development and diagnosis. Hence, PEDALE aims to be highly valuable for diagnosis (teacher’s perspective) and understanding the own learning progress (students’ perspective).

The proposed system will be used by teachers during classroom instruction to get a detailed diagnosis about their students’ competencies. The students are instructed to use the software within a fixed time period (e.g. 40 minutes, depending on test configuration) to solve the diagnostic tasks, each student at an individual computer. During the time the students work with the software the teacher can monitor as well as participate in the process. With the help of a specific control panel that is activated if a teacher logs into the scenario the teacher can get an overview about the whole classes’ progress as well as over certain events. It provides a filter-based search interface to see answers in the database by student or by task, with or without feedbacks (see fig. 4). The teacher can select a particular solution to be displayed like the feedback giving students see it. The teacher can simply look at the given feedbacks as well as give individual feedback to specific students himself. The control panel can slide up and down to overcome overlapping due to screen size restrictions.

Role Model

The users of PEDALE belong to two user groups: teachers and students in secondary schools. The teachers have the role of editing, changing and storing the scenario setups with the appropriate authoring software. In the player software they have a ‘bird’s eye view’ over the scenario and can see which student has solved which tasks, given which feedback and so on (see below). The students are the second role. They open the configured scenario in their player software and solve the prepared tasks, give and receive feedback.

Authoring and Multi-Player Environment

Beside other application areas, the design of educational software faces the problem that the main experts (e.g. teachers) for the content used in the software are not programmers and vice versa. To decouple the dependencies during development a feasible approach is to provide authoring software for teachers to create content and configure the application behavior independently from programmers who otherwise would need to implement this. A second component is a player that displays the configured test interface and content to the students. The Authoring Tool will
be used for the setup of diagnostic tests and the input of test questions fitting the used diagnostic model. The corresponding player has to be capable of displaying the new interface elements and will adapt the test course.

By this approach we benefit from two key advantages:

1. the use of an authoring environment for teachers makes it easy to create class-specific e-learning content and can lead to better learning results (Mehm, 2010),
2. the use of a software-based player component provides a comfortable way of data retrieval for retrospect diagnostic purposes. Real-time results, quantitative and qualitative measures can be displayed in a specific teacher’s view optimized for supervision, as well as in a student’s view comprising his individual quantitative and qualitative measures.

A diagram of the software components with their key functionality and the data flow are displayed in fig. 1. The work with the software is arranged in three phases:

First, the Assessment Setup with teachers authoring, creating or selecting the desired test questions and setup the characteristics like duration, amount of peer assessment and the class setup (students).

Second, during the Assessment students load the configured test via their player software and work through the diagnostic assessment in the classroom (displayed as Student A). In the first phase of the assessment the students solve machine-analyzable tasks. On the base of these tasks a first diagnosis is generated automatically and returned to the students after they went through all the tasks of the first part. The second part of the assessment asks the students to evaluate solved problems regarding the correctness and the solution process. The answers to these solved problems are open test questions and are displayed to peer students (e.g. student B gets a solved problem of student A and vice versa). The solved problems are retrieved from the tool’s data repository and the player decides which of the related solved problems matches best to be displayed. A Peer Matching Algorithm will be developed that takes into account students’ current skill competence profiles and test performance.

The given peer feedback is then stored for later review. Additionally, a second player version is provided to teachers for monitoring the students’ progress and for final review of all solved problems.

In a final Feedback phase the students are provided with all their assessment results and peer feedback, as well as a feedback from the teacher.

Adaptive Diagnostic Model

As a sound diagnosis of the students’ current state of knowledge is required for effective and individual learning and teaching, we use the diagnostic instrument developed in the 3-year project HEUREKO (Bayrhuber et al., 2010). Within the project a competence model for the mathematical domain “functions and graphs” for lower secondary
level students was developed. Focus of the model is the heuristic use and change between the fundamental mathematical representations (numerical, graphic, symbolic, verbal) what can be considered as a significant competence of mathematical problem-solving and modelling (Bayrhuber et al., 2010). Theoretical didactic models of ability that have proven successful at a national as well as an international level were operationalized and empirically assessed in order to provide an empirically grounded instrument for diagnosis and instruction that can be applied to school practice. The Rasch analyses proved a four-dimensional model to be the best predictor. Furthermore, the separateness of these dimensions could be shown. Latent class analyses indicate that seven typical competence profiles can be identified empirically across the model dimensions (Bayrhuber et al., 2010). The resulting competency model here provides the basis for a diagnostic instrument for mathematical competencies in the domain “functions and graphs”, while at the same time offering approaches to instructional support. The underlying model maps four dimensions of competencies on three levels of mastery. The first two levels comprise tasks that require a predefined input like multiple choice, decisions and numerical solutions, plotting points, intercepts or intersections. The highest level comprises open format replies like describing and reasoning.

We are transferring the paper-based tests about the understanding of mathematical functional dependencies into a software-representation and provide an user-interface that allows students to choose between and produce verbal expressions, to draw graphs, to develop algebraic terms and to note and complete numerical representations.

About ¾ of the questions can be assessed automatically by the software as the solutions and results are definite. Variants of correct and incorrect students’ solutions are taken from the results of the HEUREKO-Research Project. The questions that ask for open text input and the corresponding given answers (Solved Problems) are assessed by the teacher and peers while the student continues solving the next tasks. PEDALE uses the results to update the internal didactic learner model and select further questions accordingly. This adaptive diagnosis is possible without risking the comparability of the results due to the didactic model behind. The test questions are all categorized into several dimensions mapping exactly the tested competencies. Consequently the use of the appropriate didactic model avoids the Diagnosis Adaption Problem stated above. Still it can utilize the findings of flow theory research and adaptation. From the adaptive diagnosis approach we convey the first research question to be answered by evaluation:

*RQ1: Does the Enhancement of diagnosis functionality with adaption enhance the learning outcome and acceptance by students?*

**Peer Assessment**

The test itself will be organized into several parts, each containing questions for specific dimensions of the model. With the completion of one part of the underlying diagnostic model a student (Student B) is asked to review so called solved problems of this domain. These are questions that display the approach and/or solution of another student (Student A) and that ask student B:

- to decide whether or not the approach is correct and to rate the confidence of the given evaluation on a five-point-Likert-scale,
- give qualitative feedback on where things were done well, which mistakes can be identified or where insufficiencies were found,
- give hints and advice how the solution could be improved or solved alternatively and finally
- self-evaluate how helpful the given feedback might be for the addressed peer on a five-point-Likert-scale.

In order to give a constructive and helpful feedback each student has a feedback guide at his desk which contains guiding questions for writing a good feedback. The feedback guide is structured by what sort of solutions the students might find and differs between the given solution is ‘correct’, ‘incorrect’ and ‘there’s no solution’.

The peer assessment helps solving the Computer Diagnosis Problem. It enables us to provide open test questions with PEDALE and still get a reasonable assessment result. The learners’ assessment of peer solutions is of great value for the learning process as it prompts the students to reflect a given solution and set it in relation to their own approach and knowledge. In doing so students are encountered with (a) real solutions and (b) approaches and mistakes of students with same social and learning background (Hilbert et al., 2008).
RQ2: Does assessing solutions of other students enhance learning? Do students gain a better awareness of their own knowledge about the assessed domain?

For peer assessment the effects of social networks have to be taken into account. Conflicutive forces influence the student’s motivation to invest time and energy in providing a good or average feedback to peers. Research in Social Network Analysis shows complex interdependencies between individuals in a social network. Studies show for settings in which people feel themselves as part of a common organizational team (like a school or class) a strong motivation to help each other with constructive and qualitative feedback (Constant, 1996). However, in a classroom environment a competitive situation and complex social interdependencies can exist. The influence on the peer feedback in this scenario remains an open research question. We investigate with one setup for evaluation, whether students provide more appropriate feedback to peer students when names are displayed or when the solution and feedbacks are displayed in an anonymous way. It is expected that students in general have the desire to see and comment other students’ solutions as research for computer-supported collaborative learning environments indicates (Stepanyan et al., 2009). The proposed peer assessment setup is expected to support group learning aspects with knowledge sharing through feedback and to prevent the Individual Group Assessment Problem, because the students still carry out the test parts independently from each other.

RQ3: Which impact on acceptance of peer assessment has social anonymity? Is the perceived usefulness of giving and receiving feedback when the solutions and the feedbacks are anonymized?

Provision of Feedback

When the assessment time is over students are provided with a direct feedback. The tool returns an evaluation of the machine-analyzable questions as well as the feedback given by peers and the teacher. As Social Network Analyses indicate, the level of trust plays a major role for giving advise and critics (Petróczi et al., 2006; Golbeck, 2005). The transferability of effects of trust and closeness for classroom settings remains to be explored. As students share a more similar cultural background, language and interests with their peers as they do with the teacher, it is expected that feedback of other students is valued as a positive additional learning source. As the overall feedback is displayed after the test, it does not raise the Individual Group Assessment Problem.

RQ4: Are students more motivated to use the tool when they have the possibility to reflect other students’ solutions and can give feedback?

Peer Matching Model

For each student the actual performance in the scenario (correct and incorrect solutions to tasks), the current math proficiency level (last math mark), gender and age are stored in the role model. In an extra questionnaire the learning style preferences are investigated and added to the model afterwards (see evaluation). As it remains uncertain which criteria should be considered to which degree for matching the peers for feedback provision and receiving, the model will store the mentioned parameters, but not use them for matching in our model so far. The authors expect to find indicators for optimal matching by analyzing statistically dependencies between the described criteria and the perceived usefulness of received feedback (rated by the students individually). Currently the model will be optimized to take criteria into account for distributing the matching randomly among all participating students that each student gives and receives a balanced amount of feedbacks. By matching the students automatically by computer-algorithms PEDALE helps solving the Peer Matching Problem as teachers do not need to match the students manually.

RQ5: Which influence have gender, math proficiency level and learning style on the perceived usefulness and acceptance of feedbacks by students?

Supervision

While the students are working with the software the teacher can monitor the classes’ overall progress as well as individual student’s solutions and feedbacks. Teachers can monitor the task solutions through a teacher supervision
panel which allows them to filter the collected information according to their diagnostic or instructional interest. They can supervise all solutions to a specific task, all feedbacks to a specific solution or to a specific task, all solutions and feedbacks a specific student has submitted or received or watch the number of solved tasks in a general overview. Additional to monitoring the student’s work, the teachers can intervene by writing feedbacks to a particular student’s solution themselves or give hints how to solve the task when a student is stuck with a particular task. If desired teachers can intervene as well when an incorrect or inadequate feedback is given.

**Implementation**

**Authoring and Multi-Player Environment**

To provide a software tool for classroom learning the appropriateness for the specific classroom situation and the teacher acceptance depends on the configurability and content changeability. This must be easily achieved by domain experts (e.g. teachers) who normally do not have extensive programming skills.

We decided to build on two software components developed in our own research group, because they are easily extendable and proved their flexibility in several projects.

*StoryTec* (Mehm, 2010) allows teachers to set up the classroom characteristics and select, change or create the tasks and their order in the scenario setup without any programming skills necessary. More precisely *StoryTec* is based on the principles of Digital Storytelling. The flow of activities that later occur in the player is visualized to the author (e.g. the teacher) for editing by a graph of connected elements called scenes (see fig. 2). The appearance of scenes can be set up in a WYSIWYG-like editor. Besides video, sound, text-explanations and images, interactive elements like text-inputs, multiple-choice and handwriting support can be used for the scene design. Flow characteristics like time restrictions for single scenes or groups of scenes can be set. Teachers can configure which task scenes should be automatically assessed and specify the conditions. For task scenes that are not automatically assessed the teacher can configure the conditions for peer review (see III.D).

By manipulating the properties of scenes in several provided text fields, checkboxes and dropdowns the parameters are set to define whether a scene is an instructional one, a math task to be solved and stored to the database or a scene to request or display feedback. Teachers can easily arrange the scenes, connect them as well as create and group new tasks to be solved. The scenes can be cascaded to group elements and inherit properties from others. For the PEDALE scenarios the scene types for (task) result storage, (task) containers, giving feedback and displaying feedback have been added. Further details are omitted here and can be requested from the authors if the reader has interest in more technical details.

Based on our research we found the following setup of scenes for a scenario recommendable as a basis for individual adaption (see fig. 2):

1. solving two closed-format tasks on a comparably easy level, followed by automated diagnosis of the performance,
2. solving two open-format tasks and sending them to the system,
3. giving up to four times feedback to such open-format tasks’ solutions of peers (depending on the time spent in the previous steps. The less time was spent in step 1 and 2, the more often feedback should be given),
4. reviewing received feedback,
5. re-editing formally not correctly solved tasks (or skipping in case of all correct),
6. equally to step 1. (solving two closed-format tasks)
7. equally to step 2. (solving two open-format tasks) and finally
8. a last review equally to step 4.

Beside the authoring tool *StoryTec* there is the player software *StoryPlay* (formerly known as *BatCave*) (Mehm, 2010a) for the students that loads all the data for the configured scenario and is capable of displaying the tasks, connecting with the database to read and write the task answers and finally controlling the flow of the scenario as configured. It has been extended to display the feedback requesting dialog and has a multi-user capability to request login-information and store as well as receive written solutions, handwriting notes and feedback elements to and from the database.
Both components, authoring tool and player, use the XML-based format for narrative game-based learning objects to exchange all dependencies and rules of the classroom scenario elements (Göbel et al., 2010). *StoryTec* as well as *StoryPlay* are flexibly extendible and proofed their validity as authoring and player software already for learning scenarios in the research field of Serious Games (Mehm, 2010a; Göbel et al., 2009).

![Image of StoryTec and StoryPlay](image)

**Figure 2**: StoryTec (left) and StoryPlay (right) displaying the same math task scene (all texts in German)

**Adaptive Diagnostic Model**

For evaluation of the stated research questions we re-created several math tasks from the paper-based tests of the underlying diagnostic model as math task scenes in the authoring software *StoryTec*. This includes tasks with multiple-choice answers and open-format questions with the text-prompt to use the digital pen for algebraic, numeric or graphic approaches. As it is not the focus of the upcoming evaluation, not all dimensional dependencies are assessed and learned in the current setup. All mathematical tasks that are assessed here require a transformation from graphical to algebraic representations of functional dependencies. As respected in the proposed solution model of PEDALE it is afterwards desired to re-create further math tasks of differing representational changes as well and evaluate the adaption and selection of the tasks from different diagnostic model categories, too.

**Peer Assessment**

For better insight into the student’s approaches, especially for the open-format tasks, PEDALE supports the use of digital pens, mouse and Microsoft stylus events. To allow for a handwriting and calculation that is as natural as possible, in our scenario students use a digital pen and write directly on regular paper. The pen movements are recorded and stored as an image. Several pages are possible for longer calculations. These images are then embedded in the respective task and are re-displayed to the peer students when students give feedback to each other, to the teacher during review of stored solutions and to the student himself when revising wrongly solved tasks.

When students are requested to give feedback to a peer’s solution the best fitting candidate is selected from current database status. The selection is mainly based on the number of already received feedbacks to balance the knowledge exchange. If several candidates exist that have the same low number of received feedbacks, the candidates are further sorted binary by several subsequent criteria:

1. selecting a solution to assess, that is not of the same math task that has been assessed before (ensuring task variety),
2. selecting solutions of candidates, that have not already received feedback by the user (ensuring feedback sender variety),
3. selecting solutions of candidates, where the math task has not been solved by assessing user herself before (ensuring assessment variety for assesses).

Further criteria considered for later implementation depending on the evaluation results are gender, math grade and current scenario performance, learning style preferences, social network relations.
The assessing student is provided with the respective task and the peer’s solution, i.e. the hand-written notes, and a feedback panel with structured feedback criteria (see fig. 3). Here the student assesses the correctness and completeness and gives constructive feedback. Additionally he is asked to rank his own certainty of giving feedback. Using the scale-based judgment the software can update the learner models of both assessor and the person assessed.

After the provision of qualitative feedback in the free-text field the student finally assesses the usefulness of his own feedback and then clicks the known play-button to jump to the next StoryPlay scene. The feedback and selections are stored to the database.

Figure 3: Peer Assessment screen with a solution of a peer student displayed on the left and the guiding questions to provide feedback on the right (enlarged as the image in the middle). The calculations of the peer can be opened in popup windows (see image on the right) (all texts in German)

Receiving provided Feedback

The qualitative feedback is displayed to the receiving student in a similar screen-layout (see fig. 4). When studying the received feedback students can freely switch between the several feedbacks by using an additional list or drop-down selection in order to compare different hints easily. Their own written notes can be re-opened for inspection. Additionally each feedback can be rated by the receiver on a five-point-Likert-scale. This rating can be taken into account for the evaluation to correlate the self-estimation of feedback-senders about their feedback usefulness and their self-assurance about the correctness and with the perceived usability.

Figure 4: Example of the Student Feedback Receiving screen where the provided feedbacks are listed on the lower right, can be rated with stars and the own written solutions (left) can be re-opened in popup. On the right top the provided feedback of the peer (all texts in German)
Supervision

We enhanced the player software *StoryPlay* with a specific control panel that is activated if a teacher logs into the scenario. It provides a filter-based search interface to see answers in the database by student or by task, with or without feedbacks (see fig. 5). The teacher can select a particular solution from the list. It is displayed equally as to the feedback giving students. The teacher can look at the given feedbacks as well as provide individual feedback to specific students himself. The control panel can slide up and down to overcome overlapping issues due to screen size restrictions.

![Control Panel](image)

*Figure 5: The additional control panel for teachers to list, filter and select items for review and the possibility to give feedback as well in an extra window opening by pressing the button (all texts in German)*

Evaluation Approach

Before the main evaluation we conducted a pilot study with mathematics and teacher education experts in order to test the feasibility and acceptability of the software. The results involved the need of some minor design improvements as well as the suggestion of a teacher supervision panel and are already integrated into the concept introduced here. The main evaluation focusses on the technical feasibility and the validation of the electronic instrument at the beginning of the school year 2011/12 in seven 9th grade classes of three different secondary schools. The assessed competencies are expected to be available for the students but need to be revived and checked by the teacher in order to get a status quo and plan the next instructional unit. The evaluation of the computer-supported diagnostic instrument will last three weeks with a 1.5 hour diagnostic test each week in seven school classes in parallel. The tests for the classes will consist of the following setups, each in one class:

Setup $\alpha$: A PEDALE-based test with no intermediate feedback function as a reference group for feedback and social ties. (The reference group gives and receives feedback only at the end of the course after all the tasks solving is over.) The tasks are solved without any name recorded with the task solution. In short this setup variant is called “no feedback, anonymously”.

Setup $\beta$: A PEDALE-based test with no intermediate feedback function but name recording with the task solution as a reference group for feedback. In short: “no feedback, namely”.

Setup $\gamma$: A PEDALE-based test with intermediate feedback to and from peers without displaying names in the task solutions and the feedbacks as an indicator of the influence by feedback functionality. In short: “feedback, anonymously”.
Setup δ: A PEDALE-based test with intermediate feedback to and from peers with displaying names in the task solutions and the feedbacks as an indicator of the influence by social ties between students and anticipated competition. In short: “feedback, namely”.

Future Work

Due to the former research it is expected to find evidence for RQ1, RQ2 and RQ4 to support the core concept of the stated approach of combining diagnosis with peer assessment for learning. Competitiveness and complex social interdependencies between individuals in school class has certainly to be taken into account as a factor for peer assessment. However because the field evaluation described above cannot affect any marks of students and covers the mathematical content of the previous school year, students might not consider competitiveness during the peer assessment. Social interdependencies however might still be relevant in the evaluated scenario. This situation might result in no significant proof for RQ3. If there is evidence supporting RQ3, considering this aspect in further projects seems to be reasonable. Last, if beside RQ4 indications for RQ5 can be found, we will further intensify our investigation of social interdependency factors and peer matching criteria.

Technical issues for future work include a widening towards the inclusion of game elements in order to increase motivation and flow experiences. Additionally the creation of a web-based solution is considered that can be used by students not only in the classroom, but also accompanying homework to assess peers’ solutions, receive feedback and develop knowledge together in a Social Adapting Diagnostic and Learning Environment.

Conclusion

In this paper some crucial challenges of everyday classroom instruction have been described which affect traditional as well as technology-enhanced teaching. Although some problems remain open it has been shown how far digital learning environments could support those central processes of diagnosis and learning through knowledge exchange among peers. Hereby, the integration of the social network in the classroom seems to be a vital element of classroom learning that needs to be considered in digital environments as well. In our evaluation we focus on critical design challenges and analyze the benefits and potential that such a learning software has for teaching and learning.

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References


Teaching Web Security using Portable Virtual Labs

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ABSTRACT

We have developed a tool called Secure WEb dEvelopment Teaching (SWEET) to introduce security concepts and practices for web application development. This tool provides introductory tutorials, teaching modules utilizing virtualized hands-on exercises, and project ideas in web application security. In addition, the tool provides pre-configured virtual computer for laboratory exercises. This paper described the design of the tool and the resources it offers to instructors. We also discussed a hands-on course module on cryptography.

Keywords

Virtualization, cryptography, web security, and software assurance

Introduction

Web application security has been an emerging topic as an increasing number of commercial applications are designed based on eXtensible Makeup Language (XML) and using HyperText Transfer Protocol (HTTP) for communications. In particular, social networking sites have been used intensively among the college students, and the security and trust of such sites needs be addressed. The Internet business services are typically implemented by integrating existing services. The XML technology is the foundation of data integration across heterogeneous IT systems. The web service is a particular implementation technology of the Internet business services, and service-oriented architecture (SOA) specifies the software architecture based on the service integration. Information security has become an important issue for Internet business services in different disciplines such as banking, finance, and telecommunications.

The teaching materials in web application security are very limited. There is a need for developing new teaching materials that can address the emerging security issues in web application development. The materials should also be able to attract the students’ interests and provide them with the hands-on experience in learning these new concepts.

We have developed a new secure web development teaching tool, called SWEET (Secure WEb dEvelopment Teaching), for undergraduate and graduate computing courses. The purpose of the project is to enhance the students’ learning experience in computing through a standardized computing environment and teaching modules in secure web development.

Literature Review

Many computer security educators have designed courseware with hands-on laboratory exercises for computer security courses but none of them focus specifically on secure web development. Whiteman and Mattord (Whitman & Mattord 2005) has compiled a set of hands-on exercises for introductory computer security classes. The SEED (Developing Instructional Laboratories for Computer Security Education) project (Du & Wang 2008) has provided a comprehensive list of computer security exercises including system security, network security and web security, to a lesser degree at this point.

Web security textbooks suitable for undergraduate courses are also very limited. Most textbooks in computer security published in recent years only have a chapter or a section in web security with a limited overview of Secure Socket Layer (SSL) and certificate authority. While there are many books in web application vulnerabilities (Lawton 2007; Andrew & Wittaker 2006; Fisher, 2006; Garfinkel 2002; Shah 2007; Stuttard & Pinto 2007) and secure programming (Graff & van Eyk 2003; Grembi 2008), they are designed for practitioners, not for undergraduate students.

Web security professional organizations have provided abundant learning materials in secure web development, which are good information sources for our project. The Open Web Application Security Project (OWASP) is an
international group of experts and practitioners who are dedicated to enabling organizations to develop, purchase, and maintain secure applications. The Web Application Security Consortium (WASC) is an international group of experts and industry practitioners who produce open source and widely accepted security standards for the web. WASC has constantly posted current information in securing web applications, such as security exploits and its incident database.

The Development of SWEET

Virtualization

SWEET utilizes the virtualization technology to configure a computing environment needed for the hands-on laboratory exercises. The virtualization of a computer means to run emulator software on a computer (host computer or physical computer) to emulate another desired computer (virtual computer). The host computer and the virtual computer can run the same or different operating systems. For users, a virtual computer looks just like an additional window on their computer desktop and functions like another physical computer. Figure 1 illustrates a Linux virtual computer operated on top of a Windows host computer. Users can switch back and forth between the virtual computer and the host computer. The host computer and the virtual computer can share both data and Internet access. Users can also conduct the same computing tasks, such as installing new software, on the virtual computer as if they would do on the host.

Virtualization has been widely used ranging from commercial systems to educational demonstrations. Various virtualization emulators have been developed, such as VMware (VMware browser is a product of Vmware, Inc. Information is available at www.vmware.com.) or Microsoft Virtual PC (Virtual PC is a product of Microsoft. Information is available at http://www.microsoft.com/windows/virtual-pc/), Virtual Box (Virtual Box is an open source software under the terms of the GNU General Public License (GPL) version 2. It is provided by Oracle. Information is available at https://www.virtualbox.org/), and Citrix ZenApp (ZenAPP is a product of Citrix. Information is available at http://www.citrix.com/English/ps2/products/product.asp?contentID=186). We developed SWEET virtual computers using VMware but the virtual computers can be imported to other emulators if needed. In our project, a virtual computer is implemented by a folder of 2-8 GB files and is based on Ubuntu Linux but can be run on top of MacOS, Windows or Linux.

A virtual computer can run on either a remote server (server-side virtualization) or on the user computer (client-side virtualization). We developed the SWEET virtual computers to run locally on the user computers. The client-side virtualization offers us several advantages over the server-side virtualization. First, the client-side virtual computers do not require Internet connections which make it possible to isolate web security exercises to the local network and prevent the spilling effect of the exercise results on the Internet. Second, the virtual computers greatly reduce the pressure on the servers and network bandwidth. As a result, the laboratory exercises will not be hindered by network performance. Third, the virtual computers are portable. Since there are virtualization emulators on all operating systems and a virtual computer is implemented as a folder of files, the students could hold the folder on a portable disk and use, pause, and resume work on the same virtual computer on different host computers at university labs or at home. Since a virtual computer is simply a folder of files or a self-extracting file after compressing, it can be distributed through web downloading, USB flash disks, or DVD disks. In addition, the virtual computers are flexible, which can be run on computers in a general purpose computer laboratory, students’ laptops or home computers, with
only emulators installed. Moreover, the virtual computers are easy to maintain since any software changes will be done on the virtual computers which can be easily copied, modified and distributed. Last but not the least, the virtual computers are cost effective. Both students and faculty do not have to purchase additional hardware or software except for the emulator, which is mostly free for educational purchases.

**Resources for Instructors**

SWEET (All the teaching materials can be downloaded from our project web site http://csis.pace.edu/~lchen/sweet/) is designed for sophomore to junior undergraduate students who have only taken an introductory level of programming as well as some computer networking concepts. The modules are also suitable for the Information Systems/Information Technology Masters’ students who have only an introductory background in computing. The project provides tutorials on Linux, HTTP and HTML for students who are not familiar with these topics. Instructors can require students to review these materials depending on their previous experience and background.

SWEET also provides teaching modules which include web security concepts in a nutshell and structured hands-on laboratory exercises that illustrate the concepts. For example, when discussing secure web transactions, the module introduces certificate authority, Secure Socket Layer and HTTPS, and the hands-on exercises contain step-by-step instructions for creating a web certificate and installing it on a web server using OpenSSL. These exercises, implemented in a pre-configured virtual computer, allow students to review the contents of the lecture and to apply what they have learned to solve a well-structured web security problem. Research has shown that students expressed enthusiasm over their learning topics when they utilized hands-on exercises in computer security classes (Chen & Lin 2007) since they can see theories in action.

SWEET laboratory exercises are built upon a pre-configured virtualized platform that has a virtualization layer and an application layer. The virtualization layer is a pre-configured VMware virtual computer running Ubuntu Linux. The application layer includes a web server, a database server that connects to the web server, web applications, a proxy server for monitoring the web traffic, and other web security and programming tools. All applications pre-installed on the SWEET virtual computer are open-source software.

Project ideas are also provided for instructors who would like students to conduct a term project. These project ideas are not well structured but enable students to stimulate new ideas and to develop problem solving skills based on what they have learned from the teaching modules. For example, the SWEET virtual computer is pre-configured with an intentional vulnerable web server. Students can investigate the security problems of the web server, such as configuring HTTPS for the server or scanning the server for vulnerabilities.

**SWEET Teaching Modules**

We have incorporated the software assurance paradigm (Komaroff & Baldwin) in SWEET. Software assurance ensures the web applications to be as they are designed by examining each stage in the life cycle of the web application development. In particular, security maturity models provide a template for integrating security practices into the business functions and goals of software systems. Although these models are reference models rather than technical standards, they offer practitioners’ perspective on how to incorporate security practices in the software development process. Three such models have been proposed lately including OWASP’s Software Assurance Maturity Model (OpenSAMM) (OWASP 2009), Build Security In Maturity Model (BSIMM2) (McGraw 2006; McGraw & Chess 2010) and Microsoft’s Security Development Lifecycle (Howard & Lipner 2006). These models map security practices into the stages of software development life cycle. The goal is to incorporate security practices in software during its developmental stages instead of just testing for security vulnerabilities after the software being completed. While considering web application security, software developers could utilize the security maturity models to determine what security practices they should consider and when the security practices can be adopted.

SWEET teaching modules include four teaching modules introducing web and security technologies, and another four modules introducing web security threats and security practices based on OWASP’s OpenSAMM, which does not tightly directly to specific vendors. The eight teaching modules are described as below:
1. Web application development overview: The module covers HTML form and its various supported GUI components; URL structure and URL rewrite; HTTP basic requests; the four-tiered web architecture and web server architecture and configuration; session management with cookies, hidden fields, and server session objects; CGI vs. Java servlet/JSP web applications. The laboratory exercises guide students to set up a web server and observe HTTP traffic via a web proxy.

2. Introduction to web services: The module covers the service-oriented computing and architecture; web service for integrating heterogeneous information systems across the networks; service interface methods and method invocation data with XML dialects WSDL and SOAP. The laboratory exercises guide students to configure and secure a simple web service application.

3. Introduction to cryptography: This module covers basic principles in encryption; digital signature and digital certificates. The laboratory exercises guide students to use Gnu Privacy Guard (Gnu Privacy Guard is the open source implementation of the Open PGP defined by IETF RFC4880. The software is available at http://www.gnupg.org/) for private key and public encryption.

4. Secure web communications: The module covers Secure Socket Layer (SSL) protocols; public key infrastructure, certificate authority; digital certificates; certification validation and revocation; online certification status protocol. The laboratory exercises guide students to configure SSL on a web server and to create and sign server certificates.

5. Threat assessment: The module covers the secure software development life cycle, risk analysis, and web application security risks. The laboratory exercises examine various web security threats, such as poor authentication, SQL injection and cross-site scripting, by illustrating these vulnerabilities using OWASP’s WebGoat.

6. Security testing: This module covers concepts in design review, code review, and penetration testing. The laboratory exercises guide students to conduct security testing on a pre-configured vulnerable web server.

7. Vulnerability management: The module covers management and mitigation of web server vulnerabilities. The laboratory exercises guide students to fix the vulnerabilities of a web server and to mitigate a man-in-the-middle attack towards the server.

8. Java security: This module introduces the concepts and tools for supporting Java security framework and key management. The laboratory exercises guide students to review Java security framework, secure file exchange using Java security API and keys, and protect their computers from insecure Java applications.

A Sample Module on Cryptography

Cryptography is the foundation for Java security and web security. This module contains five sections: concepts, lab objectives, lab setup, lab guide, and review questions. The concept section introduces the symmetric secret key ciphers, public key ciphers, hash function and digital signature, and digital certificates. For example, the digital signing of a document is visually described with Figure 2 and the authentication and validation of a signed document is visually described in Figure 3.

![Figure 2. Digital Signing of a Document](image-url)
The lab objectives are

- Learn and practice how to use MD5 and SHA1 to generate hash codes of strings or large files, and verify whether a downloaded file is valid;
- Learn and practice how to use GPG to encrypt/decrypt files with symmetric algorithms;
- Learn and practice how to use GPG to generate public/private key pairs and certificates, distribute the certificate with public key to a friend, let the friend encrypt a document with the public key, and let the key owner decrypt the document with the private key.

The lab setup section includes detail instruction of how to download and install an Ubuntu v10.10 virtual machine, and how to install the PGP and GnuPG-Agent packages.

**A Detailed Lab Guide for GPG**

This lab exercise guides you to practice the above PGP (GPG) concepts with GPG in our Ubuntu10 VM.

1. **Create Linux Accounts for Alice and Mike**
   - Launch your Ubuntu10 VM, and start a terminal window.
   - Run command “sudo adduser alice” to create a Linux account for Alice. Create Alice’s password.
   - Run command “sudo adduser mike” to create a Linux account for Mike. Create Mike’s password.
   - Run command “sudo visudo” to launch file “/etc/sudoers.tmp” in a text editor, insert the following two lines at the end of the file, and then use Ctrl+O to write out the revised contents, and use Ctrl+X to exit the editor. This step will enable Alice and Mike to use “sudo”.
     
     ```
     alice   ALL=(ALL) NOPASSWD: ALL
     mike    ALL=(ALL) NOPASSWD: ALL
     ```

2. **Run as Alice and Mike in two terminal windows**
   - In the terminal window, run “sudo login”, and then login as Alice.
   - Start a new terminal window, run “sudo login”, and then login as Mike.

3. **Generate keys for Alice**
   - In Alice’s terminal window, run “gpg --gen-key” to generate her public and private keys. Enter “DSA and Elgamal” for key kind, 2048 for key size, “key does not expire” for key expiration date, “Alice” for real name, alice@pace.edu for email address, “Alice’s keys” as comment, and “Alice’s passphrase” for passphrase. You may need to type over 284 random keys to generate enough entropy so the keys could be created.

4. **Generate keys for Mike**
In Mike’s terminal window, run “gpg --gen-key” to generate his public and private keys. Enter “DSA and Elgamal” for key kind, 2048 for key size, “key does not expire” for key expiration date, “Michael” for real name, mike@pace.edu for email address, “Mike’s keys” as comment, and “Mike’s passphrase” for passphrase. You may need to type over 284 random keys to generate enough entropy so the keys could be created.

5. Export Alice’s public key to Mike
   - In Alice’s terminal window, run “gpg --armor --output alice-pk --export alice@pace.edu” to dump Ali’s public key in file “alice-pk”。 You can run “more alice-pk” to review the public key.
   - Run “sudo cp alice-pk /home/mike” to copy Alice’s public key file “alice-pk” to Mike’s home folder.
   - In Mike’s terminal window, verify the existence of file “/home/mike/alice-pk” by running “ls” in Mike’s home folder ~ (/home/mike).
   - In the same Mike’s terminal window, run “gpg --import alice-pk” to import Alice’s public key into Mike’s key store.
   - In the same Mike’s terminal window, run “gpg --edit-key alice@pace.edu” to enter the editing session for Alice’s public key. Type sub-command “sign” to sign this key with Mike’s key. You will be asked to enter Mike’s passphrase, which is “Mike’s passphrase”. Type sub-command “check” to review who is on the signature list of Alice’s public key, and we will see Alice (self-signature) and Mike on the list to confirm the validity of the key. You type sub-command “quit” to exit the editing session, and confirm to save the changes.

6. Create and encrypt a message
   - In Mike’s terminal window, run “cat > msg-to-alice” followed by the ENTER key, type “Alice’s secret message”, and then type key combination Ctrl+D to close the file. You just created a new text file “msg-to-alice” with contents “Alice’s secret message”.
   - In Mike’s terminal window, run “gpg --recipient alice@pace.edu --output secret-to-alice --encrypt msg-to-alice” to generate a new file “secret-to-alice” containing the encrypted version file “msg-to-alice”.
   - In Mike’s terminal window, run “more secret-to-alice” to review the encrypted version of the message.
   - In Mike’s terminal window, run “sudo cp secret-to-alice /home/alice” to copy file “secret-to-alice” to Alice’s home folder “/home/alice”.
   - In Alice’s terminal window, run “ls” in Alice’s home folder ~ (/home/alice) to verify the existence of file “secret-to-alice”.

7. Decrypt the message
   - In Alice’s terminal window, run command “gpg --output msg-from-mike --decrypt secret-to-alice” to decrypt the contents of file “secret-to-alice” and save the result in a new file “msg-from-mike”.
   - In Alice’s terminal window, run “more msg-from-mike” to review the decrypted message from Mike.

Course Adoption Experience

Each SWEET teaching module is self-contained. They can either be adopted separately in various courses or together in one course. We have currently incorporated SWEET modules in three courses at Pace University: Web Application Security, Computer Security Overview, and Internet and Network Security. Web Application Security is a graduate level course for the information assurance concentration and the other two are undergraduate courses. SWEET modules were integrated into these courses as reading materials, laboratory exercises and course projects. To learn about students’ course experiences, we surveyed them in Fall 2009, Spring 2009 and Fall 2010 semesters. The survey responses included positive statements in each of the following four categories: lecture materials, laboratory exercises, mapping between lecture and lab, and overall impact of these modules on their learning experience and career. A web-based survey using 5-point Likert scale (5 indicating strongly agree and 1 indicating strongly disagree) was conducted at the end of each semester. A total of 122 students responded to the survey. Table 1 lists the classes and the means and standard deviations for all questions in each class survey.

Our results showed that the students invested a significant amount of time (1-3 hours per module on average) in completing their laboratory exercises. They generally agreed that the course materials were well planned (mean: 4.10
and standard deviation: 0.89 for questions regarding the lecture materials), the exercises drawn their interest (mean: 4.15 and standard deviation: 0.84 for questions regarding the laboratory exercises), the exercises helped them with learning the course materials (mean: 4.08 and standard deviation: 0.87 for questions regarding the mapping between lecture and lab), and they would be interested in taking additional courses in information assurance or pursuing a career in this area (mean: 4.00 and standard deviation: 0.91 for questions regarding the overall impact).

Table 1: A list of Pace courses evaluated and student survey responses

<table>
<thead>
<tr>
<th>Class name</th>
<th>Semester</th>
<th>Number of students</th>
<th>Number of student responses</th>
<th>Mean (Standard deviation)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Web Application Security</td>
<td>Fall 2009</td>
<td>47</td>
<td>30</td>
<td>3.97 (0.95)</td>
</tr>
<tr>
<td>Computer Security Overview</td>
<td>Fall 2009</td>
<td>20</td>
<td>14</td>
<td>4.34 (0.55)</td>
</tr>
<tr>
<td>Internet and Network Security</td>
<td>Spring 2009</td>
<td>11</td>
<td>10</td>
<td>4.35 (0.32)</td>
</tr>
<tr>
<td>Web Application Security</td>
<td>Fall 2010</td>
<td>45</td>
<td>40</td>
<td>4.13 (0.75)</td>
</tr>
<tr>
<td>Computer Security Overview</td>
<td>Fall 2010</td>
<td>34</td>
<td>28</td>
<td>3.92 (0.93)</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>157</td>
<td>122</td>
<td>4.08 (0.81)</td>
</tr>
</tbody>
</table>

The results also showed that the teaching modules received similar feedback from different student groups but were more positively acknowledged by students with employment experience. Using regression analyses and t-tests, we found that there is not enough evidence to support significant differences between graduate (57.4%) and undergraduate (42.6%) students and between male (73.8%) and female (26.3%) students. Encouragingly, we found that students with employment experience (41%) are 21% (using two-tailed t-test with 95% confidence interval) more satisfied with SWEET than the ones without employment experience. The result implied that students’ work experiences might have contributed to their acknowledgement to the importance of the hands-on experiences provided by SWEET modules.

The SWEET teaching modules were also adopted by New York City College of Technology, which is a minority university. Several of the SWEET projects were incorporated in two undergraduate courses at New York City College of Technology: Web Design and Information Security. Furthermore, the SWEET teaching modules were posted on a project web site of both institutions to help other institutions to adopt or incorporate it into their Web/Security courses and to train more qualified IT professionals to meet the demand of the workforce.

The SWEET modules could also be integrated into several relevant computer science courses since web computing highlights the application of the latest computing concepts, theory and practices. For example, in a few lab hours, the "Service Oriented Architecture" module could be integrated into Computer Networking or Net-Centered Computing courses to provide the students with hands-on exposure to the latest concepts and technologies in integrating heterogeneous computing technologies over the Internet; and the "Threat Assessment" module could be adopted by a database course for students to understand how SQL injection could be used by hackers to attack server systems.

Conclusions

Secure web development is an important topic in assuring the confidentiality, integrity and availability of the web-based systems. It is necessary for computing professionals to understand web security issues and incorporate security practices during the life cycle of developing a web-based system. Our secure web development teaching modules (SWEET) provides the flexible teaching materials for educators to incorporate this topic in their courses using hands-on exercises and examples.

References


Semantic Linking of Learning Object Repositories to DBpedia

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ABSTRACT
Large-sized repositories of learning objects (LOs) are difficult to create and also to maintain. In this paper we propose a way to reduce this drawback by improving the classification mechanisms of the LO repositories. Specifically, we present a solution to automate the LO classification of the Universia repository, a collection of more than 15 million of LOs represented according to the IEEE LOM standard. Although a small part of these LOs is correctly classified, most are unclassified and therefore searching and accessing information is difficult. Our solution makes use of the categories provided by DBpedia, a linked data repository, to automatically improve its classification through a graph-based filtering algorithm, which selects the most suitable categories for describing a LO. Once selected, these categories will classify the LO, linking its classification metadata with a set of DBpedia categories.

Keywords
Learning objects, IEEE LOM, Linked data, Ontologies, DBpedia

Introduction
In the last decade important efforts have been made in the development of standards to represent the characteristics (or metadata) of learning objects (LOs) with the objective of facilitating its sharing and reuse among different learning designs and also among different educational tools (Wiley, 2000). Two standards stand out over others, Dublin Core (Hillmann, 2005), oriented to the modeling of any digital resources, and IEEE LOM (IEEE LTSC, 2002), developed specifically to represent the pedagogical features of the resources used in learning activities.

In parallel with this effort, the technology of LO repositories has been developed, which led to the apparition of frameworks, architectures, and protocols for the publication, querying and reuse of LOs through its metadata (Massart, 2006; Ternier et al., 2009). LO repositories can be characterized from several perspectives (McGreal, 2008), among which we highlight (i) whether they contain generic LOs that cover a number of different pedagogical subjects or domains; and (ii) whether they model the semantics of LO metadata through an ontology. These semantic repositories are particularly interesting because they improve the interoperability among educational tools, support semantic queries about the of the repository content, and facilitate the automatic generation or enrichment of some metadata (Soto Carrión et al., 2007). This paper focuses on this last point and specifically on how the categories of the LOs might be automatically generated or annotated through ontologies.

The description of LO metadata through ontologies and the development of techniques for its automatic generation has attracted great interest in recent years (Pahl & Holohan, 2009). In (Jovanovic et al., 2006) authors propose to use two different ontologies for representing LOs: one for describing their content and structure, and the other one for modeling their categories. In this work the annotation of categories is a semi-automatic process that requires the participation of users to manually select the domain concept at which the LO belongs to. In (Dodero et al., 2005) an authoring collaborative environment that allows incorporating domain ontologies to the vocabulary managed by the users in the annotation is presented. In (Al-Khalifa & Davis, 2007) authors have developed an ontology-based architecture to generate LOs from folksonomies that users create manually through tagging. The annotation process consists of mapping the tags of the folksonomy to the instances of the ontologies used to describe semantically the LO domain. In (Nesic et al., 2011) a set of ontologies are defined to represent the domain, social context, and structure of LOs, which are documents shared in a social network. In this work, users manually create the LO metadata through a graphical interface that generates the RDF instances of the ontologies. However, the previously described approaches share the same drawbacks:

- They use ontologies that describe the semantics of a particular domain, making impossible to apply these approaches to the creation/maintenance of cross-domain LO repositories.
- The annotation process is at most semi-automatic, requiring users to annotate and validate the correctness of the metadata. However, it is not feasible to apply this strategy to large-sized repositories.
To address these drawbacks some approaches that generate automatically LO metadata based on cross-domain ontologies that contain a large number of instances (densely populated) have appeared. Niemann & Wolpers (2010) describe semantically the named entities extracted from the manual annotation of LOs (locations and persons) with instances of DBpedia (Bizer et al., 2009a). In Svensson et al. (2010) the contextual information, mainly geographical, associated to LOs created with mobile devices is also annotated with DBpedia. However, authors do not detail whether users manually carry out this annotation or not. Brut et al. (2011) propose the automatic annotation of the LO categories through a technique that combines TFIDF with latent semantic indexing and with WordNet-based processing to look for the best ontology instances that describe the LO content edited by the teacher. Their solution uses the ACM hierarchy of Computer Science topics to describe the LO categories, although this hierarchy cannot be considered a large-sized cross-domain ontology.

From the perspective of the annotation of LO categories, the former approaches present another important drawback: they look for a unique instance that completely characterizes the LO. Finding that unique instance is somehow too optimistic because the only possibility is to find the same or a very similar instance in the repository. Since this is unlikely, our approach focuses on extracting the relevant terms of the LO, on finding the better instances that characterize these terms in DBpedia, and on extracting the most suitable categories that classify these instances.

In this paper, we present an approach to classify LOs with a set of categories automatically extracted from DBpedia. The objective is to relate the text-based fields of IEEE LOM that describe the subjects of the LOs, which are contained in the Universia digital library (Universia, 2012), with a set of categories semantically described in DBpedia. For this purpose, (i) we obtain the relevant terms that characterize the LO content and then (ii) we use these terms to filter the instances of DBpedia. The categories of these instances, those that better describe the LO, are then (iii) linked to the classification field of the LO, creating a semantic link between the LO repository and DBpedia. Finally, (iv) the LOs of Universia are represented as instances of an ontology that models the IEEE LOM standard. In addition, (v) these instances are published as a semantic LO repository by following the principles of linked data (Bizer et al., 2009b).

The rest of the paper is organized as follows. Firstly, the Universia repository is presented. In the next sections we describe of our approach to annotate the LO classification with DBpedia categories. Finally, the last section summarizes the main contributions of the paper.

Universia learning objects repository

Universia repository is composed of 213 collections of LOs in different languages and domains, totaling 15,750,979 academic resources, including theses, scientific publications, and journals, among others. All available resources are represented according to IEEE LOM and are classified using the UNESCO classification (UNESCO, 1988). However, most of LOs do not fit in the UNESCO classification and thus are never categorized or are categorized by non-standard topics introduced by the person in charge of creating the LOM instance in the external library. Thus, only a small part of the LOs in the repository are correctly categorized, specifically 1% of the Universia content. This information loss leads to incomplete or incorrect searches, and consequently, the time required to find a LO also increases.

Our approach tries to solve this drawback by automatically providing an appropriate classification for LOs. The proposed classification mechanism uses the categories that the Wikipedia provides through the DBpedia ontology. Therefore, all objects in the repository will be automatically and uniformly categorized, complementing these objects already classified with the UNESCO classification, and providing a more reliable classification mechanism to non-scientific and non-technological LOs.

Linking learning object repositories to DBpedia

IEEE LOM (IEEE LTSC, 2002) is a standard that defines a schema composed of seven elements that allow representing metadata about a LO: general information about it (General); technical (Technical) and pedagogical (Educational) characteristics; its authors and different versions; (Lifecycle); its intellectual
property rights and conditions of use (Rights); its relations with other LOs (Relation); its subject in relation to a particular classification system (Classification); the comments related to its educational use (Annotation); and the information about the metadata itself (Meta-Metadata). Figure 1 shows part of the metadata of a LO about Chinese language that is stored in Universia where the descriptive information provided by the General element is highlighted.

In order to integrate the Universia LOs with DBpedia it is necessary to translate the LOM specification to an ontology. For this purpose, we used the LOM part of the IMS LD ontology described in Amorim et al. (2006). Figure 2 shows part of this ontology, where the concepts General and Classification are gray colored to highlight the LOM elements that could be semantically linked to external linked data repositories. In this paper we focus on annotating the Classification concept. The objective is to relate two attributes of the Taxonpath concept, the attribute taxon, which specifies the category, and the attribute source, which sets the classification system used, with instances available in DBpedia (Bizer et al., 2009a). DBpedia is an ontology-based repository automatically created by extracting structured information from Wikipedia. Currently, this semantic repository contains over 3.64 million entities; 2.7 million links to images; 6.3 million links to web pages; 2.9 million of YAGO categories (Suchanek et al., 2008); and 740,000 Wikipedia categories. These last categories are represented in DBpedia as instances of SKOS concepts and are associated to other instances of the DBpedia ontology through some of the SKOS taxonomic relations: dcterms:subject, is dcterms:subject of, skos:broader, and is skos:broader of. Therefore, once a DBpedia category has been selected, adding Taxonpath instances to a LO involves the steps shown in Figure 2.

- The value of the source attribute of Taxonpath is DBpedia because it is the classification system used to assign the categories to LOs.
- The taxon attribute of Taxonpath has two attributes: (i) the id attribute whose value is the URI of the DBpedia category (http://dbpedia.org/page/Category:Scheduling_%28computing%29 in Figure 2); and (ii) the entry attribute whose value is the skos:prefLabel of the DBpedia category (Scheduling_%28computing%29 in Figure 2).

![Figure 1. Example of the metadata of a LO retrieved from the Universia library](image-url)
Approach description

In order to obtain the DBpedia categories for a given LO, it is necessary to process its metadata to extract the relevant terms. However, not all the LOM elements contain valuable information to get these terms. For instance, all the fields of the Technical element and some fields of the Lifecycle element do not provide valuable useful information to determine the LO topic. Thus, we have focused on some of the fields of the General element: the title, which contains the LO name; the description, which briefly details its content; the keywords, which lists important LO topics; and the coverage field, which provides information about the time, geographical or cultural features.

Table 1. LOM fields that are analyzed for extracting the relevant terms that characterize a LO

<table>
<thead>
<tr>
<th>LOM element</th>
<th>Description</th>
<th>GLOBE frequency</th>
<th>Universia frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Title</td>
<td>Name given to the LO</td>
<td>1.00</td>
<td>0.99</td>
</tr>
<tr>
<td>Description</td>
<td>A textual description of the LO content</td>
<td>0.87</td>
<td>0.73</td>
</tr>
<tr>
<td>Keywords</td>
<td>A term list describing the LO topics</td>
<td>0.57</td>
<td>0.68</td>
</tr>
<tr>
<td>Coverage</td>
<td>The time, culture or geography of the LO</td>
<td>0.10</td>
<td>0.13</td>
</tr>
</tbody>
</table>

Figure 2. Link between a semantic LO repository and DBpedia through the dcterms:subject property
Taking this into account, the conceptual architecture of our approach is depicted in Figure 3.

Figure 3. Processing tasks to obtain the DBpedia categories that annotate the Taxonpath element of the IEEE LOM

This solution receives the LOM metadata elements, specifically the General element with the descriptive information about the LO, and processes these inputs in two steps in order to:

- **Obtain the LO relevant terms.** In this step we combine natural language processing (NLP) techniques with term similarity techniques to determine the relevant terms that characterize the LO, which we call the context of the LO. The relevance of each term will depend on the LOM element in which it appears. For instance, if the term is part of the title, it is usually more relevant than if it appears in the description. In this paper, the weight of each IEEE LOM element was set according to Ochoa et al. (2011), who performed a statistical analysis of the frequency of use for each LOM element in a set of repositories that belongs to the GLOBE alliance, containing 630,317 LOs. As Table 1 shows, the frequencies of the fields of the General element for the GLOBE and Universia repositories are very close. Therefore, we assumed the relevance weights obtained for the GLOBE repositories to generalize our approach.
Obtain DBpedia categories. In this second step we use the relevant terms of the LO metadata to obtain the set of nodes of the DBpedia RDF graph that semantically describe each of these relevant terms. Several of these nodes are DBpedia categories that must be identified and ranked to be directly linked from the Taxonpath element of the LO. Note that the nodes of the RDF graph are also instances of the ontology that models the concepts of DBpedia. Therefore, in this paper the terms node and instance are used indistinctly.

In the next two subsections we will detail the techniques and algorithms that have been applied to obtain the LO relevant terms and the DBpedia categories.

Obtaining relevant terms

In order to extract automatically the relevant terms that characterize the content of a LO, we analyze metadata elements by applying NLP techniques. For each LO, three different analyses are carried out:

- **Morphological analysis.** With the GATE tool (Cunningham et al., 2002) we get the grammatical category of each term that appears in the LO metadata elements. Particularly, this analysis (i) excludes the terms whose grammatical category is not representative enough to characterize LO metadata, such as conjunctions, prepositions or determiners; and (ii) identifies nouns (e.g., pyramids), compound nouns/multiset of terms (e.g., Ancient Egypt), and proper nouns (e.g., Keops).

- **Similarity analysis.** Since a term may appear in different forms, we create clusters of terminological similarity in order to increase the frequency of occurrence of a term and to avoid terms that arise from the same root. In our approach, we have applied SoftTFIDF (Cohen et al., 2003) to calculate the similarity among terms. SoftTFIDF is a hybrid distance function that combines a token-based distance function, in this case TFIDF (Sparck Jones, 1972), with an edit-distance, in this case Jaro-Winkler (Winkler, 1999). The selection of SoftTFIDF is based on the results obtained in (Cohen et al., 2003), where it has proved to be one of the metrics with best results in returning adequate values for terms with a common root, such as comparing "Egypt" with "Egyptian". Let $S$ and $T$ be term multisets extracted from the LO (e.g., $S$ and $T$ may be "Director-General Smith" and "Director Smith", respectively; i.e., $S$ would be a multiset of 3 terms and $T$ would be a multiset of 2 terms), SoftTFIDF is formulated as follows, where $w$ represents a term of $S$:

$$
SoftTFIDF(S,T) = \sum_{w \in S} TFIDF(w,S) \cdot TFIDF(w,T) \cdot D(w,T)
$$

(1)

where:

- The functions $TFIDF(w,S)$ and $TFIDF(w,T)$ measure the cosine similarity of the term $w$ in the multiset of terms $S$ and $T$, respectively. TFIDF calculates this similarity taking into account (i) the frequency of the term in the multiset (e.g., "Director" occurs 1 time in $S$), and (ii) the inverse frequency of the term in the corpus of documents, in this case the set of terms extracted from the collection of LOs. This inverse frequency provides the significance of the term in the collection, starting from the hypothesis that terms with higher frequency provide less information.

- $D(w,T)$ is the second similarity function and it is implemented with the Jaro-Winkler function $dist(w,v)$. Edit-distance functions map a pair of strings/terms $w$ and $v$ to a number $r$, which represents the cost of best sequence of edit operations (character insertion, deletion, or substitution) that convert $w$ to $v$:

$$
D(w,T) = \max_v dist(w,v)
$$

(2)

For example, the evaluation of SoftTFIDF for the former example returns that "Director-General Smith" and "Director Smith" have a degree of similarity of 0.81649 since the two words are very close.

In our approach, we compare all the words of the LO (or multiset of terms) with each other. Terms with high similarity are then clustered and the term representing each cluster, called nominal term, is selected based on one of the following criteria:
o If there is a single proper noun within the cluster, this term is considered as the nominal term. For instance, Egypt is the nominal term for the cluster whose members are {Egypt, egyptian, old egyptian}.
o If there is more than one proper noun, the proper noun with highest frequency is considered the nominal term of the cluster. The frequency of these terms is calculated via (3).
o If there is not a proper noun, the term with highest frequency within the structure of the LO is selected. This frequency is also calculated through (3).

- **Frequency analysis.** The frequency is a quantitative measure that provides the number of occurrences of a given term in the LO metadata. In our case, it provides the relative frequency of a term $t$ in the metadata field $\alpha$:

$$tf_{\alpha} = \log \left( \frac{n_{t,\alpha} + \text{sim}_{t,\alpha}}{|\alpha|} \right) + 1$$

where:
- $|\alpha|$ is the number of terms in a field $\alpha$ of the General metadata, such as title or description.
- $n_{t,\alpha}$ is the number of occurrences of $t$ in $\alpha$.
- $\text{sim}_{t,\alpha}$ is the number of occurrences of terms that are syntactically similar to $t$ in $\alpha$. Let $\theta$ be the threshold for considering two terms in the same syntactic cluster:

$$\text{sim}_{t,\alpha} = |\text{SoftTFIDF}(t, t')| > \theta$$

- **Relevant terms ranking.** As result of applying sequentially the former three analysis, we obtain a set of terms for the LO, each one ranked according to its frequency in the LO. However, our ranking does not only consider the frequency, but it is based on the TFIDF measure that is adapted to the characteristics of our LO. Thus in our approach, the relevance $r$ of a term $t$ in a LO is calculated as follows:

$$r_t = \frac{\left( \sum_{\alpha \in \text{LO}} tf_{t,\alpha} \cdot p_{\alpha} \right) \cdot idf_t}{\sqrt{\sum_{t' \in C} \left( \sum_{\alpha \in \text{LO}} tf_{t',\alpha} \cdot p_{\alpha} \right) \cdot idf_{t'}}}$$

where:
- $\alpha$ is a field of the General metadata.
- $p_{\alpha} \in [0,1]$ is the corresponding weight associated to the $\alpha$ metadata field.
- $C$ is the Wikipedia corpus. Three aspects motivated the selection of Wikipedia. Firstly, because the variety of domains is a crucial feature for obtaining reliable results, and Wikipedia is a free encyclopedia divided into 12 major subject branches, containing thousands of topic lists. Secondly, because it is a huge collection of documents, and it is well known that larger collections usually provide better search results. Finally, because our objective is the annotation of LO categories with the DBpedia instances, which have been automatically extracted from Wikipedia.
- $idf_t$ is the inverse document frequency, and measures the general importance of the term. This function is calculated as follows:

$$idf_t = \log \left( \frac{|D|}{1 + |\{d \in D. tf_t = 0\}|} \right)$$

where:
- $|D|$ is the number of documents in the Wikipedia corpus.
- $|\{d \in D. tf_t = 0\}|$ is the number of documents in the Wikipedia where the term $t$ appears.

With this approach, a high relevance is reached by a high term frequency in (3) and a low document frequency in (6). Finally, each term of the LO is evaluated and ranked according to (5). Terms with $r_t > \beta$ are considered as relevant and are therefore included in the context of the LO, where $\beta$ is the relevance threshold.

Table 2 shows the relevance of some terms of a LO about the Chinese language introduced in Figure 1. As we can see "Chinese", "Mandarin", and "Chinese language" are the most relevant instances of DBpedia for characterizing that LO. In this example, the less relevant instances are generic concepts, such as "Writing", "Asia", or "Literature".
This is not the usual result since generic concepts are penalized by the IDF part in (6). However, the metadata fields of this example are very short and do not provide enough information to retrieve more specific instances.

Table 2. Relevant terms obtained for the Chinese Language LO shown in Figure 1

<table>
<thead>
<tr>
<th>Term (t)</th>
<th>DBpedia resource</th>
<th>Relevance ($r_2$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chinese</td>
<td><a href="http://dbpedia.org/resource/Chinese">http://dbpedia.org/resource/Chinese</a></td>
<td>1.00</td>
</tr>
<tr>
<td>Mandarin</td>
<td><a href="http://dbpedia.org/resource/Mandarin_Chinese">http://dbpedia.org/resource/Mandarin_Chinese</a></td>
<td>0.71</td>
</tr>
<tr>
<td>Chinese language</td>
<td><a href="http://dbpedia.org/resource/Chinese_language">http://dbpedia.org/resource/Chinese_language</a></td>
<td>0.60</td>
</tr>
<tr>
<td>Chinese studies</td>
<td><a href="http://dbpedia.org/resource/Sinology">http://dbpedia.org/resource/Sinology</a></td>
<td>0.59</td>
</tr>
<tr>
<td>Asian American studies</td>
<td><a href="http://dbpedia.org/resource/Asian_American_studies">http://dbpedia.org/resource/Asian_American_studies</a></td>
<td>0.59</td>
</tr>
<tr>
<td>Course</td>
<td><a href="http://dbpedia.org/resource/Course">http://dbpedia.org/resource/Course</a></td>
<td>0.59</td>
</tr>
<tr>
<td>Writing</td>
<td><a href="http://dbpedia.org/resource/Writing">http://dbpedia.org/resource/Writing</a></td>
<td>0.50</td>
</tr>
<tr>
<td>Asia</td>
<td><a href="http://dbpedia.org/resource/Asia">http://dbpedia.org/resource/Asia</a></td>
<td>0.42</td>
</tr>
<tr>
<td>Literature</td>
<td><a href="http://dbpedia.org/resource/Literature">http://dbpedia.org/resource/Literature</a></td>
<td>0.40</td>
</tr>
</tbody>
</table>

Obtaining DBpedia categories

The first step when dealing with large amounts of data, as in DBpedia, is to filter non-relevant information, that is, to only retrieve nodes related to some of the terms that characterize the LO. In our approach, we consider that the relevance of a node (or equivalently an instance) in a RDF graph is given by its relations. For example, the dbpedia:Chinese_language node has several relations to other nodes, and depending on the values of the target nodes of these relations, its relevance might vary. In this paper, we consider two types of nodes:

- **Primitives** are literal-based nodes, such as texts, dates, or numbers.
- **Resources** are instances of a class, which have at least one relation to another primitive or resource node.

Two examples of relations to primitive nodes are the rdfs:label and dbpedia-owl:abstract properties, which are used to describe the resource through a literal (rdfs:literal) and a text (xsd:string), respectively. These former relations are very useful to determine the relevance of a node since they are mandatory and thus always included in every node. However, other relations clearly do not contribute to obtain that relevance and are directly discarded, such as relations to numbers, external links, measures (e.g., latitude and longitude), pictures, and so on.

Table 3. Preset weights of relations used during the relevance calculation of DBpedia nodes

<table>
<thead>
<tr>
<th>Relation name</th>
<th>Weight</th>
<th>Relation range</th>
</tr>
</thead>
<tbody>
<tr>
<td>rdfs:label</td>
<td>0.70</td>
<td>Primitive (rdfs:literal)</td>
</tr>
<tr>
<td>dbpedia-owl:abstract</td>
<td>1.00</td>
<td>Primitive (xsd:string)</td>
</tr>
<tr>
<td>dcterms:subject</td>
<td>0.90</td>
<td>Resource (skos:Concept)</td>
</tr>
<tr>
<td>is dcterms:subject of</td>
<td>1.00</td>
<td>Resource (owl:Thing)</td>
</tr>
<tr>
<td>rdf:type</td>
<td>0.60</td>
<td>Resource (owl:Thing)</td>
</tr>
<tr>
<td>is rdf:type of</td>
<td>1.00</td>
<td>Resource (owl:Thing)</td>
</tr>
<tr>
<td>skos:broader</td>
<td>0.60</td>
<td>Resource (skos:Concept)</td>
</tr>
<tr>
<td>is skos:broader of</td>
<td>1.00</td>
<td>Resource (skos:Concept)</td>
</tr>
<tr>
<td>rdfs:subClassOf</td>
<td>0.60</td>
<td>Resource (owl:Thing)</td>
</tr>
<tr>
<td>is rdfs:subClassOf of</td>
<td>1.00</td>
<td>Resource (owl:Thing)</td>
</tr>
<tr>
<td>default value</td>
<td>0.70</td>
<td>Resource (owl:Thing)</td>
</tr>
</tbody>
</table>

Considering this, in our approach each relation, established among resources or between resources and primitive data, is weighted ($w_r$) as a value between 0 and 1. In Table 3 we summarize the weights associated to each relation type. For example, rdfs:label and dbpedia-owl:abstract have an importance of 0.70 and 1.0 in the calculation of the node relevance, respectively. The first ten rows of the table show the relations that most influence the process of determining the relevance of a node. The rdfs:label and dbpedia-owl:abstract provide a text description of the instance, while the next 8 relations expand the search space to ancestors, siblings, or nodes.
with a similar subject. The last row of the table refers to the rest of DBpedia relations that might provide important information for determining the relevance of terms. Relations that point to dates, literals, strings or other non-primitive nodes are typical examples of this category. For instance, the dbpprop:dia relation, which points to resources that are dialects of the source node, is clearly relevant for the Chinese language LO, since it targets to resources related with 16 Chinese dialects, such as dbpedia:Mandarin_Chinese or dbpedia:Pu-Xian_Min. These relations are weighted with a value of 0.70.

In this approach each relation is weighted according to Vidal et al. (2011), where a machine learning approach is developed to determine the most appropriate weights for DBpedia relations. Their results showed an improvement in the precision/recall curves obtained for a set of e-learning courses.

**Filtering Algorithm**

Our filtering algorithm is performed in two steps. In the first one, and for each relevant term previously identified in the LO, a unique DBpedia node (or equivalently, a unique URI) is retrieved through the DBpedia Spotlight service. As a result the URIs corresponding to the list of relevant terms of the LO are returned. In the second step, and for each URI, a filtering process starts expanding the search space by following each one of the relations of these nodes. Notice that each explored node is also evaluated to determine whether this node is relevant or not. Relations to non-relevant nodes are discarded, and they are not included in the solution graph. This process is guided by a Depth First Search (DFS) algorithm (depth-limited) (Russel & Norvig, 2009) and gets into the node to expand, retrieves its relations and explores each relation, going deeper and deeper until it hits a relation whose range is a primitive data or the depth limit has been reached. Then DFS backtracks, returning to the most recent node it has not finished exploring. In this algorithm, the relevance of each visited node is determined as follows:

- **If the node n is a primitive data**, the relevance will depend on how many relevant terms of the LO it includes:

  \[
  \text{relevance}(n, \Delta) = \frac{\text{shared}(n, \Delta)}{|\Delta|^2} \sum_{i=1}^{|\Delta|} \left( \sum_{t=1}^{\text{r}_t} t \cdot \text{tf}_{t,n} \right)
  \]  

  where:
  
  o \(i\) identifies the \(i\)-th term of the context \(\Delta\).
  o \(|\Delta|\) is the number of terms in the context.
  o \(\text{r}_t\) is the relevance of the \(i\)-th term of \(\Delta\) (normalized between \([0,1]\)), see (5).
  o \(\text{tf}_{t,n}\) is the frequency of the term \(t_i\) in \(n\), see (3).
  o \(\text{shared}(n, \Delta)\) is the number of shared terms between the node \(n\) and the context \(\Delta\).

- **If the node n is a URI**, the relevance is calculated by adding the weighted relevance of the target nodes \(n_t\) pointed by \(n\):

  \[
  \text{relevance}(n, \Delta) = \frac{1}{|R_n|} \sum_{i=1}^{|R_n|} \left( \frac{1}{|S_t|} \sum_{t=1}^{|S_t|} \text{relevance}(n_t, \Delta) \right)
  \]  

  where:
  
  o \(|R_n|\) is the number of different relations in which \(n\) is the source node.
  o \(|\Delta|\) is the context of the LO.
  o \(i\) identifies the \(i\)-th relation of \(n\).
  o \(w_i\) is the weight of \(i\), \(0 \leq w_i \leq 1\).
  o \(|S_t|\) is the number of instances of the relation \(t\) that have \(n\) as its source node.
  o \(t\) identifies the \(t\)-th instance of \(i\), that is, the relation \(r(n,n_t)\).
  o \(n_t\) is the target node of the \(t\)-th instance of \(i\).
The algorithm returns a set of DBpedia subgraphs, each of which (i) describes semantically a given relevant term of the LO; and (ii) is composed of a number of nodes with weights that reflect its relevance for the description of the LO content. For instance, the Chinese language relevant term of the LO shown in Figure 1 has a subgraph that contains 67 nodes.

**Ranking Categories**

Our algorithm has the advantage of returning a DBpedia subgraph and not only the most suitable node related with each relevant term. Another advantage is the content of this graph. As we described in previous sections, SKOS hierarchical relations, such as `dcterms:subject`, `is dcterms:subject of`, `skos:broaden`, and `is skos:broaden of`, are used to type and categorize the DBpedia nodes. We can therefore take advantage of these nodes to classify a LO and annotate the Taxonpath structure of LOM with these categories. For example, Table 4 lists the first ten categories retrieved for the Chinese language LO depicted in Figure 1. These categories are ordered according to their relevance for that LO. Although "Asia" is the first category and might be considered somehow too much general, the remaining categories, such as "Languages of Asia" or "Chinese Language", perfectly classify this course.

**Validation**

Figure 4 shows the quality of our filtering algorithm in terms of precision and recall, which are the two basic metrics in information retrieval systems:

\[
\text{precision} = \frac{|TP|}{|TP| + |FP|} \quad (9) \quad \text{recall} = \frac{|TP|}{|TP| + |FN|} \quad (10)
\]

where $TP$ (true positives) is the set of retrieved instances that are relevant; $FP$ (false positives) is the set of retrieved instances that are not relevant; and $FN$ (false negatives) are the set of instances that are wrongly retrieved as non-relevant.

As the curves show, our solution obtains high values of precision for low recall values. This is a desirable property that, for example, most of web search engines want to have. Since there is a huge number of documents in the web that may have some relevance for a given query, the focus of these engines is on having the higher precision for low values of recall. In our approach, the goal is to retrieve the most accurate categories for a given LO, which ensures that the first categories have a high probability of being correct annotations. For example, the DBpedia categories of Table 4 are closely related with the Chinese language LO shown in Figure 1, except the second category (Hiking trails in Asia).

Furthermore, our solution has been compared with other semantic and DBpedia-based annotation algorithms, obtaining even better results for high recall values. Specifically, DBpedia Spotlight (Mendes, 2012), OpenCalais (Thomson Reuters, 2012), AlchemyAPI (AlchemyAPI, 2012), and RelFinder (Heim et al., 2009) were considered.
only RelFinder was really comparable, because it extracts a DBpedia subgraph and not simply a unique instance. Table 5 shows the results of this comparison, which was done according to the following criteria:

- Experiments were performed with 4 test sets, each one composed of 10 LOs selected randomly from Universia.
- The same number of solutions was compared. Specifically, we have limited the comparison to the number of solutions returned by RelFinder to not bias the results.
- It was considered a depth of two levels, which is the worst scenario for our algorithm, as Figure 4 shows.

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- It was considered a depth of two levels, which is the worst scenario for our algorithm, as Figure 4 shows.

![Figure 4. Precision/Recall curves for the terms extracted from 15 courses in a wide range of domains, such as geography, history, or social sciences](image)

Table 5. Comparison of RelFinder with our filtering algorithm for 40 LOs contained in Universia

<table>
<thead>
<tr>
<th>Measure</th>
<th>Set 1</th>
<th>Set 2</th>
<th>Set 3</th>
<th>Set 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>RelFinder</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Precision</td>
<td>0.3626</td>
<td>0.3692</td>
<td>0.1897</td>
<td>0.2464</td>
</tr>
<tr>
<td>Recall</td>
<td>0.2654</td>
<td>0.3708</td>
<td>0.2762</td>
<td>0.5142</td>
</tr>
<tr>
<td>$F_1$-Score</td>
<td>0.2534</td>
<td>0.3700</td>
<td>0.2249</td>
<td>0.3331</td>
</tr>
<tr>
<td>$F_{0.5}$-Score</td>
<td>0.3379</td>
<td>0.3696</td>
<td>0.2023</td>
<td>0.2751</td>
</tr>
<tr>
<td>Our solution</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Precision</td>
<td>0.3900</td>
<td>0.3779</td>
<td>0.2754</td>
<td>0.2800</td>
</tr>
<tr>
<td>Recall</td>
<td>0.7444</td>
<td>0.7269</td>
<td>0.6695</td>
<td>0.6808</td>
</tr>
<tr>
<td>$F_1$-Score</td>
<td>0.5119</td>
<td>0.4996</td>
<td>0.3903</td>
<td>0.3968</td>
</tr>
<tr>
<td>$F_{0.5}$-Score</td>
<td>0.4311</td>
<td>0.4187</td>
<td>0.3122</td>
<td>0.3174</td>
</tr>
</tbody>
</table>

As shown in Table 5, our solution clearly outperforms RelFinder, obtaining for all the test sets a better recall and a better precision. Note that these results were obtained for a complete recall, which is a recall of 1.0, since RelFinder does not rank the solutions. We have also considered another typical comparison measure, the $F$-score metric, which is a measure of a test's accuracy:

$$F_{\beta} = \frac{(1 + \beta^2) \cdot \text{precision} \cdot \text{recall}}{(\beta^2 \cdot \text{precision}) + \text{recall}}$$  \hspace{1cm} (11)

As shown in (11), $F$-score formula ($F_{\beta}$) only considers the precision and recall to compute the score. In our tests we used (i) the balanced version of the $F$-score metric, which sets $\beta = 1$, and that can be interpreted as a weighted average of the precision and recall, and (ii) an $F$-score with $\beta = 0.5$, which emphasizes the precision over the recall. The results of the experiment for this metric are shown in Table 5, and it should be remarked that our algorithm has a better behavior than RelFinder for both the precision ($F_{0.5}$-score) and the balanced precision/recall ($F_1$-score).

Notice also the effect of the depth of exploration in the quality of results. The deeper is the exploration, better is the precision. For instance, there is a qualitative step forward between an exploration of two or three levels, as Figure 4
shows. However, the benefit of exploring deeper the DBpedia is doubtful. Each extra level implies analyzing a huge amount of nodes, so the time to obtain the subgraph increases exponentially. For example, if we suppose that each DBpedia resource has more than 40 relations (e.g. most of dbpedia-owl:Place instances have at least 62 relations), the jump from the third to the fourth level implies reviewing at least $4^{3}$ additional nodes.

The use of cloud computing and information retrieval techniques for indexing DBpedia are clear ways to improve the processing time required to annotate the LOs. Nodes may be retrieved faster, and thus we may go deeper in the search space. However, there is a second factor that prevents to explore in high levels of depth: results quality. In Mirizzi et al. (2010), authors concluded that 85% of solutions are in the first 3 levels, and that rarely nodes with high relevance are among nodes above 3 hops.

<table>
<thead>
<tr>
<th>LO id</th>
<th>Nodes</th>
<th>Categories</th>
<th>LO id</th>
<th>Nodes</th>
<th>Categories</th>
</tr>
</thead>
<tbody>
<tr>
<td>21073</td>
<td>67</td>
<td>52</td>
<td>21133</td>
<td>56</td>
<td>38</td>
</tr>
<tr>
<td>21093</td>
<td>72</td>
<td>55</td>
<td>21134</td>
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<td>23</td>
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<tr>
<td>21094</td>
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<td>26</td>
<td>21135</td>
<td>38</td>
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</tr>
<tr>
<td>21095</td>
<td>46</td>
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<td>21136</td>
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<td>11</td>
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<tr>
<td>21096</td>
<td>15</td>
<td>9</td>
<td>21137</td>
<td>79</td>
<td>58</td>
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<tr>
<td>21113</td>
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<td>21138</td>
<td>197</td>
<td>55</td>
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<tr>
<td>21114</td>
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<td>52</td>
<td>21139</td>
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<td>21115</td>
<td>3</td>
<td>2</td>
<td>21140</td>
<td>70</td>
<td>41</td>
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<tr>
<td>21116</td>
<td>45</td>
<td>23</td>
<td>21141</td>
<td>8</td>
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<tr>
<td>21117</td>
<td>9</td>
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<td>21142</td>
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<tr>
<td>21118</td>
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<td>21143</td>
<td>110</td>
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<tr>
<td>21119</td>
<td>62</td>
<td>41</td>
<td>21144</td>
<td>62</td>
<td>30</td>
</tr>
<tr>
<td>21120</td>
<td>27</td>
<td>13</td>
<td>21145</td>
<td>53</td>
<td>27</td>
</tr>
<tr>
<td>21131</td>
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<td>21146</td>
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<tr>
<td>21132</td>
<td>33</td>
<td>26</td>
<td>21147</td>
<td>70</td>
<td>33</td>
</tr>
</tbody>
</table>

The use of cloud computing and information retrieval techniques for indexing DBpedia are clear ways to improve the processing time required to annotate the LOs. Nodes may be retrieved faster, and thus we may go deeper in the search space. However, there is a second factor that prevents to explore in high levels of depth: results quality. In Mirizzi et al. (2010), authors concluded that 85% of solutions are in the first 3 levels, and that rarely nodes with high relevance are among nodes above 3 hops.
Implementation

Following the principles of linked data, we developed a semantic repository containing the Universia LOs. Specifically, this implementation is composed of:

- A dataset that contains more than 60,663 LOs described in LOM. Current version is mainly composed by LOs of economy, physics, mathematics, and so on. Each LO is identified by a public URI and linked automatically to a set of SKOS-modeled categories of DBpedia. Table 6 summarizes the number of nodes and categories retrieved for some of the LOs analyzed. So far the mean of categories per LO is 28.70.

- A service lookup that allows users to find LOs by related keywords. In this case, related means that either the title (lom:Title), description (lom:Description), or keywords (lom:Keyword) of a General instance, or an author (lom:Entity) of a Contribute instance, or a category (lom:Entity) of a Taxom matches the keyword-based query. For example, Figure 5 shows some of the results obtained for the Chinese keyword, including the Chinese Language LO depicted in Figure 1, which is classified and linked to DBpedia categories. This service lookup is available at http://tec.citius.usc.es/universia/lookup.

- A SPARQL endpoint through which a user may write a SPARQL query and retrieve the result in several formats. For example, Figure 6(a) shows the screenshot of the SPARQL endpoint with a query about the categories of the Chinese language LO, while Figure 6(b) presents the results obtained as solution for that query. Although these results are shown in HTML format, many other formats, such as RDF/XML or JSON, may be returned. This SPARQL endpoint is available at http://tec.citius.usc.es/universia/sparql.

![Figure 6. Screenshots for a query to the SPARQL endpoint of the Universia semantic repository](attachment:image.png)
Conclusions

An approach for the extraction and the annotation of the LO categories of the Universia digital library has been presented. This approach improves the current solutions of the state of the art because (i) it supports the automatic selection of the most suitable categories ranked according to its relevance to the LO; and (ii) it is a cross-domain approach that looks for the solution in more than 700,000 categories of DBpedia. Furthermore, this approach can be easily extended to manage other linked data repositories different from DBpedia since the filtering algorithm explores the RDF graph independently of concrete relations of the DBpedia ontology. In fact, it only depends on the SKOS vocabulary.

Finally, the Universia repository has been transformed in a semantic LO repository following the principles of linked data. Thus, LO metadata can be directly accessed through a URI and retrieved by means of both a SPARQL endpoint, that answer semantic queries, and a service lookup, that solves keyword-based queries.

Acknowledgements

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References


Learning-by-Teaching: Designing Teachable Agents with Intrinsic Motivation

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ABSTRACT

Teachable agent is a type of pedagogical agent which instantiates Learning-by-Teaching theory through simulating a “naïve” learner in order to motivate students to teach it. This paper discusses the limitation of existing teachable agents and incorporates intrinsic motivation to the agent model to enable teachable agents with initiative behaviors in fulfilling three perspectives of educational requirements, namely Teachability, Practicability, and Affectivability. The proposed Motivated Teachable Agent is realized by a goal-oriented approach, and through executing the goal hierarchy, the teachable agent can follow its intrinsic motivation to initatively interact with students and arouse their learning interest. A use case study illustrates the effectiveness of this approach.

Keywords

Learning-by-teaching, Intrinsic motivation, Teachable agent, Goal-oriented approach

Introduction

Thousands of years ago philosopher Lucius Seneca stated, “We learn by teaching”. This idea, nowadays, evolved to a modern educational theory called “Learning-by-Teaching”. It has been widely observed that when students teach their peers they learn much better than they learn for themselves (Allen & Feldman, 1976; Gartner, 1971), since they no longer passively receive knowledge from teachers but perform as a young tutor to actively master the learning content. In light of this theory, a new type of pedagogical agent, Teachable Agent (TA), emerged in 1990s. Teachable agents are computer agents that allow students to teach them and in this way improve the learning of students per se (Biswas, et al., 2005).

Many researchers worked on designing TAs in their virtual learning environments (Ailiya, et al., 2011; Chou, et al., 2003; Kauchak & Eggen, 1997; Leelawong & Biswas, 2008; Matsuda, et al., 2010; Obayashi, et al., 2000). Three advantages of TAs include that TAs can increase student’s knowledge reflection and self-explanation (Roscoe & Chi, 2007), help them structure and reorganize their knowledge (Fantuzzo, et al., 1992), and promote students to take the responsibility of learning. However, the limitation of existing TAs lies in the fact that they do not take the initiative in the interactions with students. The interaction between TAs and students is important for facilitating a better learning, so a TA should be more active and should avoid responding to students passively (Biswas, et al., 2005; Ogan, et al., 2012).

To overcome the limitation, we look into the field of computer agents. One of the focuses is to embody autonomous behaviors in the agent systems. In particular, the agent autonomy refers to allowing agents to decide whether or not to perform a certain action by themselves. Motivated by the concept of “intrinsic motivation” from psychology, agent researchers from Intrinsically Motivated Agent (IMA) consider an agent as intrinsically motivated when its behavior is engaged in “for its own sake”, other than driven by a specific “externally-directed” problem (Singh, et al., 2005). If a TA could have intrinsic motivation, the autonomous behaviors of the agent can be derived based on its own interest, and a diversity of agent abilities can be naturally presented under a unified sense of “self-willing”. Motivated by this, this paper aims to propose a Motivated Teachable Agent (MTA) which incorporates intrinsic motivation to agent modeling and synthesizes various behaviors of TAs into a full play. However, readers may have a question: what does it mean by an agent’s initiative? Several researchers discussed their opinions: (1) (Singh, et al., 2010), from an evolutionary perspective, considered “reproductive success” as the drive for agents to behave proactively; (2) (Baranès & Oudeyer, 2009) designed robots to pursue activities for which “learning progress is maximal”; (3) (Merrick, 2010) considered agent's self-motivated exploration as seeking for “novelty, interest, and competence”. However, none of them is designed for educational purpose, and the agent initiative lacks an educational value. Thus, we need to define an agent model by which agent’s initiatives can be directly related to the educational requirements of a TA. The ultimate goal of designing TAs is to facilitate student’s learning and stimulate their learning interest. In this paper, we argue that TAs should satisfy the three fundamental educational requirements of Learning-by-Teaching. First, a TA should have the ability to learn new knowledge from students in order to...
encourage them to reflect the learning materials. Second, a TA should have the ability to apply the learnt knowledge, and provide feedbacks to students in order to give them an opportunity to validate and rethink their teaching. Third, a TA should have the ability to establish good relationship with students and encourage them to teach well in order to promote students to take the responsibility of learning. Besides, a TA needs to have an autonomous mechanism to organize various activities and selectively carry out the right activity at the right time. Here, we need to clarify the term “intrinsic motivation” used in psychology and in the agent field. In psychology, researchers use intrinsic motivation in contrast to extrinsic motivation, where the emphasis is to differentiate motivations along a continuum of relative autonomy and study how to motivate people to be “enjoyable” and “carry out activities on their own” (Ryan & Deci, 2000). In computer agent, researchers use this term to differentiate with “task-oriented” behaviors (Merrick & Maher, 2009), where the focus is to computationally define agent’s motivation to guide the behavior of achieving higher objectives by meshing up lower-level single isolated tasks. Our research focuses on the latter one.

To incorporate the educational requirements into TA’s intrinsic motivation, this paper proposes a new type of TA, which is motivated by the psychological needs defined in Self-Determination Theory (SDT) (Deci & Ryan, 2000). This theory stated that intrinsically motivated behaviors provided satisfaction of three psychological needs, namely, Competence, Relatedness, and Autonomy. Based on SDT, if an entity feels the necessity of pursuing a certain need, it will elicit the corresponding motivation and act towards it to avoid any dissatisfaction. In this paper, we associate the innate needs with the educational requirements, and propose a MTA which is realized by utilizing a goal-oriented approach. The proposed TA can reason and decide by itself how to select the next goal and what actions to take, and through executing a hierarchy of goals, it can follow its intrinsic motivation and interact with students by pursuing its own agenda.

In the following sections, we first review recent studies on TAs, and propose our MTA based on the educational requirements. After that, we utilize a goal-oriented modeling approach to instantiate the theoretical agent modeling to a practical implementation. An E-learning project, Virtual Singapora, is applied to demonstrate the use of the proposed TA. From the results, we show that the proposed TA is not only theoretical but also practical. Finally the paper ends with conclusions.

Related Work

Educational researchers continuously work on the idea of “Learning-by-Teaching”, which has been widely used in language teaching and other courses. Based on the pedagogical success, modern educational researchers attempted to build E-learning systems which allow students to teach “virtual students”: “Math Concept Learning System” (Michie, et al., 1989) asked students to provide example solutions to math problems; “Development Environment for an Intelligent Student in Economics” (Nichols, 1993) lead students to construct sequences of causal relations via question and answer dialogs; “A Virtual Classroom” (Obayashi, et al., 2000) required students to teach agents and observed agents’ performance in a virtual classroom; and “Diagnosis-Hint Tree” (Chou, et al., 2003) provided students a tree of possible solutions to a buggy agent and asked students to guide the agent to find the correct solutions by diagnosing the tree. However, all these systems lacked a shared representation of knowledge (Biswas, et al., 2005).

Shared knowledge representation means the knowledge is represented in a viewable, explicit, and clear way through all the interactions between students and agents such as teaching, reasoning, and answering processes. Knowledge representation directly affects students’ knowledge organization and reflection. A good knowledge representation allows students to establish a smooth communication with TAs, so that they can understand agent’s reasoning process and identify their mistakes easily. To achieve this, a TA system called “Betty’s Brain” was built by research groups in Stanford University and Vanderbilt University. Betty’s Brain provided a platform for students to teach agents through drawing concept maps. The system used exhaustive search for TAs to reason and answer student’s questions. Concept map brought students a clear graphical tool to share their knowledge with TAs. Related to Betty’s Brain, many aspects of studies were also carried on, such as learning environment design (Chin, et al., 2010; Linn, et al., 2009; Matsuda, et al., 2010), meta-cognition (Schwartz, et al., 2009), feedbacks (Tan & Biswas, 2006), student’s behavior modeling (Jeong, et al., 2008), self-regulated learning (Biswas, et al., 2009), etc.
Apart from these, a project “SimStudent” (Matsuda, et al., 2011) in Carnegie Mellon University introduced two new extensions to exploit TAs. One is providing simulated students for educational researchers to explore learning theories, and the other is building TAs as cooperated tutees for a cognitive tutoring system.

Through the history of TA development, this type of pedagogical system has been gradually improved with the deeper understanding of Learning-by-Teaching theory and the development of artificial intelligence. The emerging of 3D virtual learning environment and the evolving of agent technology give new directions for developing TAs. In this paper, we utilize a goal-oriented approach to overcome the lack of agent’s initiative by enabling TAs with intrinsic motivations.

**From Agent to Teachable Agent with Intrinsic Motivation**

After the discussion of existing TAs, this section emphasizes the modeling of the proposed MTA. It starts with a generic agent model, followed by the formalization of TA. After discussing the educational requirements of a TA, we propose the model of a MTA in light of a psychological theory SDT. The theoretical agent model will be implemented practically by a goal-oriented approach in the next section.

An agent is a system situated within an environment that senses that environment and acts on it, over time, in pursuit of its own agenda and so as to affect what it senses in the future (Franklin & Graesser, 1997). Therefore, we have:

**Definition 1**: An agent, $\text{Ag}$, is formally specified as a tuple $\text{Ag}= (E, P, R, A)$, where $E$ is the set of environment states that an agent interacts with; $P$ is the set of percepts that the agent senses about the environment; $R$ is the set of reasoning mechanisms that the agent follows to make decisions; and $A$ is the set of primitive actions that the agent can take.

The difference between modeling a TA and any other type of agent lies in the reasoning mechanism. TAs are designed for students to teach, and therefore its reasoning is mainly on how to learn from student’s teaching.

**Definition 2**: A teachable agent, $\text{TA}$, is an agent that is defined as a tuple $\text{TA}= (E, P, Rt, A)$, where $E$, $P$, and $A$ follow the definitions in Definition 1, and $Rt$ is the set of reasoning mechanisms which enable TAs to learn from students and improve students’ learning in return.

The generic TA model is illustrated in Figure 1.

![Figure 1. Generic Teachable Agent Model](image)

An agent should be designed as an active entity that continuously perceives environment, makes decisions, and acts on the environment. In this “perceive-reason-act” cycle, an agent should have its self-determination to pursue its own agenda. In other words, an agent should not only react to the external stimulus, but also be driven by its internal needs and act stimulus-independently (Merrick & Maher, 2009). This internal drive is agent’s motivation, and we will design TA’s motivations first.
To design TA’s motivations, we start with the educational requirements. As mentioned before, Learning-by-Teaching aims to achieve three educational benefits. Therefore, a TA needs to have three abilities accordingly in order to fulfill the corresponding educational requirements.

- **Teachability for improving student’s reflection on learning materials.** Teachability refers to the ability that an agent can be taught by students. This is the most natural ability a TA should have. During the teaching process, students have to reflect their knowledge they have learnt. Reflection plays a very important role during student’s learning process (N. S. Chen, et al., 2009). Therefore, teachability improves students’ self-explanation and reflection.

- **Practicability for reorganizing student’s knowledge into coherent structure.** Practicability refers to the ability that an agent can apply the learnt knowledge in the related context. This is the ability that provides students to examine their teaching effect by observing TA’s behaviors. From agent’s performance, students can rethink their teaching from a tutor’s perspective, and such teaching-and-learning context is crucial for students (Spector, 2001). If their teaching works, students receive a sense of accomplishment enhancing their self-efficacy; if not, they can refine their teaching approach. A student will learn more from the interaction with a struggling TA (Ogan, et al., 2012), since the try-and-error experience can additionally reconstruct their understandings.

- **Affectivability for promoting students to take the learning responsibility.** Affectivability refers to the ability that an agent can elicit and express emotions. Emotions are crucial for almost every aspect of students’ learning (Bower, 1992; Kim, 2004). Emotions also deeply influence the interactive experience between agents and students (Brave & Nass, 2003). With the expression of emotions, TAs can play the role of a “naïve” learner in a more believable manner, and in this way TAs will be more effective by encouraging students to be more concentrated in their teaching.

Based on the educational requirements, we define a MTA as follows:

**Definition 3**: A Motivated Teachable Agent, $\text{TA}_m$, is a teachable agent that is defined as a tuple $\text{TA}_m = (\text{E}, \text{P}, \text{Rt}_m, \text{A})$, where $\text{E}$, $\text{P}$, and $\text{A}$ follow the definitions in Definition 1, and $\text{Rt}_m$ is a motivated reasoning mechanism and is specified as a tuple of $(\text{K}, \text{M}, \text{Tr}, \text{Pr}, \text{Ar})$.

- $\text{K}$ is the knowledge that the TA learns from students;
- $\text{M}$ is the set of motivations that potentially drive the agent;
- $\text{Tr}$ is the reasoning mechanism to realize the teachability;
- $\text{Pr}$ is the reasoning mechanism to realize the practicability;
- $\text{Ar}$ is the reasoning mechanism to realize the affectivability.

To realize the teachability, practicability and affectivability, we need a mechanism to align agent’s multiple abilities with its motivations. To achieve this, we propose the MTA by the inspiration of a well-known motivation theory, SDT. We adopt the psychological needs in SDT to depict the needs of a TA, so as to elicit its intrinsic motivations. The reason that we select SDT as the psychological basis is that the starting point of SDT postulates that “humans are active, growth-oriented organisms who are naturally inclined towards integration of their psychic elements into a unified sense of self and integration of themselves into larger social structures” (Deci & Ryan, 2000). This understanding coincides with the requirements of our agent design—to meshing up isolated task-oriented behaviors in an organized manner. In particular, SDT discusses intrinsic motivation with the level of satisfaction of three psychological needs, namely Competence, Relatedness and Autonomy.

- **Competence** is related to the tendency of mastering skills, exploring new opportunities and challenges, and achieving progress in performance. Specifically, the need of competence can be divided to two aspects. The first aspect is the Need of Novelty, which reflects the need to handle new challenges. This need will drive the agent to explore the unknown area, and acquire new knowledge and skills. Therefore, this need will drive agent to achieve the Teachability. The second aspect is the Need of Performance, which refers to the need to experience oneself as capable, and to perfect skills. This need will drive agents to complete their tasks and sharpen their related skills, which matches the Practicability.

- **Relatedness** refers to the desire of forming meaningful bonds with others—to care and to be cared for. This need will drive agents to establish good relationship with students, which is related to the Affectivability.
• **Autonomy** is related to the sense of self-determination versus control. The selection of behaviors is decided by agent itself. This need will drive agent to achieve a goal that is not controlled by external, but from its own initiative. It enables TAs to manage various needs and choose proper behaviors.

The realization of teachability, practicability and affectivability can map to corresponding needs of MTA, and the needs may arouse agent’s motivations. The detailed mappings are listed in Table 1.

### Table 1. The Mapping among Agent’s Ability, Need, and Motivation

<table>
<thead>
<tr>
<th>Ability</th>
<th>Need</th>
<th>Motivation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teachability</td>
<td>Need of novelty</td>
<td>Pursuit of new knowledge</td>
</tr>
<tr>
<td>Practicability</td>
<td>Need of performance</td>
<td>Pursuit of performance</td>
</tr>
<tr>
<td>Affectivability</td>
<td>Need of relatedness</td>
<td>Pursuit of relatedness</td>
</tr>
</tbody>
</table>

Based on the discussion above, the model of MTA is illustrated in Figure 2. The motivation interpreter \( M \) resembles a rule-based system, which checks the environmental stimuli and elicits one of the motivations listed in Table 1. The three motivations execute three cycles: through the **teachability cycle** \( E \rightarrow P \rightarrow M \rightarrow Tr \rightarrow K \), TAs can learn knowledge from students; through the **practicability cycle** \( P \rightarrow M \rightarrow Pr(K) \rightarrow A \), TAs can practice what they learnt; and through the **affectivability cycle** \( P \rightarrow M \rightarrow Ar \rightarrow A \), TAs can express their emotions to students. With this agent model, the proposed agent exhibits three perspectives of needs, which can drive the corresponding motivations and further possess the three abilities. To realize MTA, we adopt a goal-oriented approach in the next section.

![Figure 2. Proposed TA’s Architecture](image)

**Modeling Motivated Teachable Agent with GoalNet**

The implementation of MTA is based on a goal-oriented approach, GoalNet (Shen, et al., 2005), in which an agent's goal is achieved through the completion of a sequence of sub-goals. It is composed of goals and transitions: a goal, represented by a node, is a state that the agent wants to achieve; and a transition connecting two goals, represented by an arc with a vertical bar, defines how to transfer from one state to another. In GoalNet, a composite goal can be further decomposed to a sub GoalNet with a set of sub goals and transitions in between. Goal decomposition allows a complex agent to be modeled under different levels of abstraction, and it is particularly useful for the design of agents in practical applications. An illustration of GoalNet is shown in Figure 3, where the composite goal (G) is decomposed into a sub GoalNet. The GoalNet has a starting goal (S) and an ending goal (E). Note that the diamond (t2) represents a special *choice* transition, where the agent decides the next goal (S1 or S2).
We adopt GoalNet, because it is natural to describe agent’s various tasks as sub goals, and aligns them well with agent’s highest goal, "to improve student's learning". This mechanism is similar to the selection of personalized learning path (C. M. Chen, 2008; Karampiperis & Sampson, 2005), but the difference is that it originates from goal setting, and it is more naturally derived from agent’s motivation. The goal decomposition allows a higher-level motivation to be seamlessly transformed to a sequence of lower-level agent goals. Such transformation bridges the gap between theoretical modeling and the concrete agent implementation. For agent design, implementation and deployment, we utilize the platform Multi-Agent Development Environment (MADE) (Shen, et al., 2005), in which the GoalNet Designer allows system designers to design a TA in a drag-and-drop manner, and the MADE Runtime facilitates the implementation and running of the system.

Motivated Teachable Agent’s Main Routine

During the life time of a MTA, the agent repeatedly senses, reasons, and acts to the environment. The repeated cycle forms the main routine of the agent and it can be represented as a GoalNet as shown in Figure 4. At the highest abstraction, this GoalNet explains the super goal of the agent, i.e. “To execute the main routine of a TA”. The agent repeatedly senses the environment and decides whether an event has been detected. If an event is presented, it interprets its motivation based on both intrinsic needs and the event; if an event is absent, the agent interprets its motivation solely based on the intrinsic needs. Note that the proposed agent is intrinsically self-motivated, in the sense that no matter whether an event is presented, the agent will proactively proceed with its routine. Agent’s motivation interpreter relies on a rule-based system, and checks the set of premises and draws a conclusion accordingly. Once the agent is motivated, the goal pursuit is initiated by selecting a corresponding sub GoalNet. The information of GoalNet is stored and retrievable from agent’s implementation repository. After that, the agent executes the GoalNet until the end of the main routine is reached.

Figure 4. Agent’s Main Routine

This main routine is designed to achieve the need of autonomy of TAs, and it is the top-level control of an agent to achieve its goals. Under this main routine, three sub goals are designed to fulfill the three specific intrinsic needs and eventually to achieve the three abilities. The sub goals include the goal “to learn from user” for teachability, “to
practice” for practicability, and “to be affective” for affectivability. We will explain the details in the following sections.

Model of Teachability Reasoning

In the pursuit of novelty, an agent is motivated to seek solutions to achieve its goal. In the context of TA, this pursuit aligns with the teachability requirement. A MTA achieves teachability through learning knowledge from students. The learning process is triggered when the agent detects that a student is approaching and the agent has not learnt valid knowledge from him. The GoalNet for modeling teachability is shown in Figure 5. The goal is “to learn from user”. To achieve this, the agent initiates the conversation by requiring teaching from the student. He may reject the agent’s request, and this simply ends the GoalNet execution and will trigger an event which is used in affectivability reasoning. Once the user agrees, a concept map is shown to the student. The concept map is utilized as an interface tool for the agent to get structured input from the student. The agent tracks the changes of the concepts and relations on the concept map updated by the student. An error checking mechanism is used to alert the student, if any syntactic error is detected. Otherwise, the agent analyzes the received input and saves to its knowledge base. The knowledge representation in concept maps is application-dependent and requires to be defined by software designers. A use case will be given in the experiment for more details.

![Figure 5. Model of Teachability](image)

![Figure 6. Model of Practicability](image)

Model of Practicability Reasoning

In the pursuit of performance, a motivated agent tries its best to behave well and achieve good feedback during its life time. From the point of view of a tutoring system, TA’s performance goal should be consistent with its learning objectives. For example, TAs try to answer questions correctly, have high score in the assessment, or deduce appropriate actions upon a situation. The performance goal is content-dependent, and is specified by software designers. Reasoning is triggered when a TA receives the knowledge, and it intends to be evaluated. The GoalNet for modeling practicability is shown in Figure 6. The goal is “to practice” by reasoning over the learnt knowledge. To achieve this, the agent starts by perceiving inquiries from the system. Questions are one type of the inquiry, if the agent is evaluated in an ask-and-answer manner. A more interactive inquiry may be asking TAs to perform a certain
task, such as doing an experiment. For either case, the agent should get feedback from the environment, and the latter allows students to have a more insightful view by observing how the agent behaves. After identifying performance goal, the agent reasons over the knowledge base for searching solutions. It is possible that due to the inaccurate or insufficient knowledge learnt from students, it may not obtain any solution. In such case, the agent alerts the student to revise his teaching. If a solution is found, the agent forms a plan to realize the solution. A plan is made up of actions that can be directly carried out by the agent, and it can be as simple as a single action, such as “choose Answer A”, or as complex as a sequence of actions. Note that TA’s solution may not necessarily guarantee a good feedback, and students are expected to observe agent’s performance and learn deeper from agent’s evaluation results.

Model of Affectivability Reasoning

In the pursuit of relatedness, an agent is looking forwards to interacting with others. The scope of affectivability of a TA is in line with agent’s relatedness pursuit, and is achievable through the elicitation of agent’s emotions. Emotion elicitation is naturally twisted with agent’s other behaviors, and it is necessary to allow affectivability reasoning running in parallel with agent’s learning and practicing. According to a well-known emotional theory, Ortony Clore Collins (OCC) (Ortony, et al., 1990), emotions are categorized into three groups, namely goal-oriented, standard-oriented, and attitude-oriented emotions. OCC uses the cognitive conditions to elicit emotions and defines the goal-oriented emotions as a type of emotional state that is elicited by comparing events with agent’s goals. In this paper, a set of events trigger the goal-oriented emotion elicitation to enrich the expressiveness of a teaching process. In total, six types of emotions (joy, distress, happy-for, pity, hope, and fear) are elicited, and the details can be found in (Ailiya, et al., 2010).

The GoalNet for modeling affectivability is shown in Figure 7. The goal is “to be affective”. To achieve this goal, both events and goals are to be analyzed. An event at time \( t \) is defined as \( \text{event}(t) = \{\text{event}_\text{content}, \text{event}_\text{endurer}\} \), where the consequence of \( \text{event}_\text{content} \) affects \( \text{event}_\text{endurer} \). The endurer can be a TA or a student. The goal is represented as \( \text{goal}_\text{of}(\text{event}_\text{endurer}) \), which is usually known as a priori. For example, the goal of a student is to teach the agent. After analysis, three types of assessments need to be carried out, namely desirability, agent’s relationship with event endurer, and the relevance of prospects. According to OCC, the details can be explained as follows: for desirability, we have \( \text{desirable}(\text{event}, \text{Goal}) \in \{\text{True}, \text{False}\} \), e.g. it is desirable for the agent to answer a question correctly; for relationship, agent’s relation with \( \text{event}_\text{endurer} \) can be itself or others; and for prospect relevance, we refer to whether the event has a delayed, rather than immediate, consequence, and we have \( \text{prospect}_\text{relevant}(\text{event}) \in \{\text{True}, \text{False}\} \), e.g. student’s start of teaching has a prospect for the completion of agent’s learning. With these assessments, we can directly apply an emotion elicitation algorithm (Ailiya, et al., 2010) to generate emotions. Finally, the TA can express its emotions to achieve the relatedness pursuit with students.

![Figure 7. Model of Affectivability](image)

Applying Motivated Teachable Agent in Virtual Singapora Project

This section explains how the proposed MTA is designed and implemented in a computer-based learning project, Virtual Singapora (VS). VS project aims to build a 3D virtual learning environment, which provides primary and
secondary school students in Singapore a culturally familiar environment to learn science lessons (e.g. transport in living things). Using the proposed approach, “Little Water Molecules” were developed as MTAs and utilized in VS project. Instead of monotonously showing how water molecules are transported from the roots to the leaves, VS brings students an exciting view by showing how water molecules explore the root of a banana tree. At the beginning of this adventure, students will meet the “Little Water Molecule”, who wants to enter the root of a banana tree. Students are expected to help the water molecule by teaching it the knowledge of plant transport systems. Through interacting with students, TAs are motivated to achieve teachability, practicability, and affectivability. The course of teaching forms a story line in the scenario setting, and it includes following scenes (with events):

- **Game Scene 1: Greeting**
  - The water molecule meets the student for the first time.

- **Game Scene 2: Learning**
  - E1: The student agrees or disagrees to teach the water molecule.
  - E2: The student starts teaching or becomes idle.
  - E3: The student inputs knowledge without or with syntax error.

- **Game Scene 3: Practicing**
  - E4: The water molecule has entered the root or has being rejected.

**Motivation Interpretation**

According to the scenes, we can design the motivation interpreter (MI) to decide when and which motivation to elicit as in Figure 2. We consider MI as a function, mapping agent’s needs \( N \) and events \( E \) to the set of motivations \( M \), i.e. \( f_{MI}: N, E \rightarrow M \). In VS, the mapping is described as follows,

- **Need: Seeking knowledge for possible solutions.** (The agent hopes to enter the root, but currently it has no available knowledge to do so); Event: The water molecule meets the student for the first time; Motivation: to learn from the student.

- **Need: Seeking good performance.** (The agent hopes to enter the root, and the knowledge is now available); Event: None; Motivation: to practice knowledge for performance.

- **Need: Seeking sentimental interaction with the student;** Event: Event 1-Event 4 described in the scene design; Motivation: to be affective with the student.

The use of MI systematically integrates various agent behaviors, and proactively takes the initiatives of the next step.

- **Teachability Design**

  For the first time, the water molecule detects a new student is approaching, and starts begging for help as they cannot enter the root of a banana tree (Figure 8 (a)). If the student accepts the request, he needs to teach via a concept map (Figure 8 (b)). Concept map with relationships among concepts is an easy-to-use tool for students to represent
knowledge. Many research has focused on how to generate concept maps and how to use it effectively (N. S. Chen, et al., 2008). We implemented a tool such that students can drag and drop concepts and relations to create the concept map. The agent converts the concept map into pieces of logic rules, which consist of premises and conclusions. After that, the generated rules are stored as agent’s knowledge for practicability reasoning.

Practicability Design

The performance goal of the water molecule is to enter the root. In order to achieve this, the agent is required to have a correct action plan. For entering the root, the water molecule needs to enter from the “Door of Osmosis”, and the ground water ratio must be greater than that of the root. Failing to do so will result in prohibition from entering.

As mentioned above, the representation of knowledge learnt takes the form of a logic rule, i.e. \( A \rightarrow B \) where A and B are predicates. For example, if the student conveys a correct concept map:

- The agent will learn \(( \text{through}_\text{oosmosis}) \land (\text{water}_\text{ratio}(\text{ground}) > \text{water}_\text{ratio}(\text{root})) \rightarrow \text{entering}_\text{root}\)
- By default, we build in some rules as agent’s prior knowledge, \( \text{enter}_\text{hole}(\text{oosmosis}) \rightarrow \text{through}_\text{oosmosis}, \) and \( \text{rain} \rightarrow (\text{water}_\text{ratio}(\text{ground}) > \text{water}_\text{ratio}(\text{root})) \).
- By rules of inference, the agent forms its action plan by entering the osmosis hole and waiting for rain.
- By carrying out the plan, the agent successfully enters the root (Figure 9 (a)). Otherwise, the agent gets blocked (Figure 9 (b)).

Affectivability Design

Events from 1 to 4 are used to elicit emotions. According to OCC, a decision table is formed to guide what emotions to generate. The details are in Table 2.

<table>
<thead>
<tr>
<th>Desirability</th>
<th>Relation</th>
<th>Prospect</th>
<th>Emotion</th>
</tr>
</thead>
<tbody>
<tr>
<td>E1, E4</td>
<td>True</td>
<td>Self</td>
<td>False</td>
</tr>
<tr>
<td>¬ E1, ¬ E4</td>
<td>False</td>
<td>Self</td>
<td>False</td>
</tr>
<tr>
<td>E2</td>
<td>True</td>
<td>Others</td>
<td>False</td>
</tr>
<tr>
<td>¬ E2</td>
<td>False</td>
<td>Others</td>
<td>False</td>
</tr>
<tr>
<td>E3</td>
<td>True</td>
<td>Self</td>
<td>True</td>
</tr>
<tr>
<td>¬ E3</td>
<td>False</td>
<td>Self</td>
<td>True</td>
</tr>
</tbody>
</table>

Note that since an event has its counterpart, e.g. agree/disagree, the negation of an event denotes the one with negative effect. Taking E2 as an example, the goal of the agent is to have good performance, and thus the event is
Results of the Case Study

VS has been deployed in Xingnan Primary School in Singapore in 2011. The field study included two groups of students from 10 to 11 years old. The treatment group had 12 students who used our prototypes to learn diffusion and osmosis through two separated sessions of forty-five minutes each. The 12 control group students learnt the same topic on standard school classes with the same learning time. Both groups conducted a pre-test and a post-test with 20 multi-choice domain questions and 2 discussion questions related to diffusion and osmosis, which were approved and later examined by the teacher. For the multi-choice domain questions, one point was given to each correct answer, zero otherwise. In the treatment group, the students achieved mean scores in pre-test (Mean = 9.32, SD = 2.90) and post-test (Mean = 11.84, SD = 2.13). We used paired samples t-test to compare the means of pre-test and post-test within the treatment group, and the result showed a significant difference with (t = 2.2, p < 0.01). For accessing the difference between two groups, we analyzed the results with Analysis of Covariance using the pre-test scores as the covariate. However, the analysis showed the treatment was not significant (F (1, 21) = 0.97, p > 0.3). Nevertheless, with respect to the discussion questions, the treatment group had many more creative ideas with diverse explanations, e.g. they illustrated various approaches to extract salt from sea water.

In our opinion, the questions we used for the pre- and post-test were more for assessing academic results in traditional pedagogy. For modern classroom, the virtual learning environment could be beneficial in improving a student’s competencies, such as reflection of one’s previous thinking, information filtering, and finding solutions from failures. However, the improvement over learning competencies cannot be directly inferred from the current design. In the future work, we aim to propose a new type of assessment, particularly for the virtual learning environment.

The treatment group also took a questionnaire of five rating questions on the scale from 1 (strongly disagree) to 5 (strongly agree) with the “Smileyometer” design (Read, et al., 2002) to evaluate the TAs from the three designing perspectives. The results are shown in Table 3.

<table>
<thead>
<tr>
<th>Tested Agent Abilities</th>
<th>Examined Aspects in Questionnaire</th>
<th>Average Rating</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teachability</td>
<td>Interest in teaching TA</td>
<td>4.25</td>
<td>0.60</td>
</tr>
<tr>
<td>Practicability</td>
<td>Interest in entering the underground world</td>
<td>4.75</td>
<td>0.43</td>
</tr>
<tr>
<td></td>
<td>Preference to view TA’s practice and exploration after the teaching process</td>
<td>4.67</td>
<td>0.22</td>
</tr>
<tr>
<td>Affectivability</td>
<td>Favorable attitude towards TA</td>
<td>4.67</td>
<td>0.22</td>
</tr>
<tr>
<td></td>
<td>Experience on interacting with TA</td>
<td>4.33</td>
<td>0.52</td>
</tr>
</tbody>
</table>

The treatment group students chose multiple ways to seek the solution after they accepted to help the water molecule. 5 students searched from textbook after the try-and-error of the concept map drawing; 1 searched from Google; 4 asked their classmates; and 2 continuously did the try-and-error playing. We believe that all these behaviors are beneficial for students to learn the domain knowledge and find the effective way to acquire knowledge. In 2010, we also conducted the test in Catholic High School (Looi, et al., 2011), the TA in the 2010 version received an overall rating of the preference 5.5 out of 7-scale. Comparing with this version, the proposed TA with intrinsic motivations had more initiative interactions with students, and the overall rating of preference was 4.53 out of 5-scale.

Conclusions and Future Work

In this paper, we proposed a new type of TA—Motivated Teachable Agent, and used a goal-oriented approach to design and implement the agent system, allowing agents to initiatively pursue its intrinsic motivations based on SDT theory. This design endowed TAs with abilities to automatically select their behaviors in virtual world according to
their motivations and environmental stimuli, and consequently improved student’s learning experience through incorporating multiple interactive behaviors and emotional expressions.

The project with proposed agents has achieved satisfactory feedback from students of secondary school (2009-2010) and primary school (2011) in Singapore. However, there are still issues which need to be addressed in the future. From the assessment result, we found that the system lacks assessment tools which can take the advantage of the virtual learning environment to evaluate student’s learning skills from analyzing their behavior data. Currently, the system assessment results were derived from students’ learning outcome and their preference to TAs by academic tests and questionnaires. However, since our project is a computer-based system, it is convenient to collect student’s learning behavior data during their play. We believe these types of data will reveal more information which cannot be discerned from traditional assessment. For instance, during the same period of time, students who attempt more tasks may possess a greater desire in learning than those who attempt fewer. Similarly, students who deal with tasks of higher-difficulty levels may have greater curiosity and may be more willing to face challenges.

In the future work, we plan to incorporate new functions into the existing system to record all types of user behavior data in the virtual learning environment. The data will be analyzed to assess student characteristics related to self-directed learning, such as self-efficacy, learning motivation, reflective thinking skills. We will also conduct more experimental and classroom field studies to assess students using both questionnaires and the collected behavior data.

**References**


Self-regulated Workplace Learning: A Pedagogical Framework and Semantic Web-based Environment

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ABSTRACT
Self-regulated learning processes have a potential to enhance the motivation of knowledge workers to take part in learning and reflection about learning, and thus contribute to the resolution of an important research challenge in workplace learning. An equally important research challenge for the successful completion of each step of a self-regulatory process is to enable learners to be aware of the characteristics of their organizationally-embedded learning context. In this paper, we describe how a combination of pedagogy and Semantic Web-based technologies can be utilized to address the above two challenges. Specifically, we demonstrate the proposed solution through the Learn-B tool that leverages ontologies to support self-regulation in organizational learning.

Keywords
Self-regulated Learning, Workplace Learning, Ontologies, Personal and Organizational Learning

Introduction

Basic modes of workplace learning include i) incidental and informal learning, which takes place as a side effect of the work, ii) intentional, but non-formal learning activities related to work activities, and iii) formal on-the-job and off-the-job training (Tynjala, 2008). Ideally, intentional learning at workplace is initiated by perceiving a gap of knowledge or competences for certain present or future tasks. This further means that knowledge workers are aware of their competences and can identify their learning needs based on the present or forthcoming requirements of a task, project, duty or any other of their responsibilities in the organization and in collaborative teams. Motivated and proactive learning, however, rarely happens in everyday work environments. Unless provided with structured learning scenarios in formal settings, most people are not proactive enough to initiate a learning process or simply do not know how to learn (Margaryan et al., 2009).

Self-regulated learning (SRL) (Zimmerman, 1989) contains motivational elements to address the above stated challenges. According to Knowles (1975), SRL refers to a process, “… in which individuals take the initiative, with or without the help of others, in diagnosing their learning needs, formulating learning goals, identifying human and material resources for learning, choosing and implementing appropriate learning strategies, and evaluating learning outcomes” [p18]. Empirical research brings evidence that, individuals who are oriented toward self-regulated enhancement of competences and excellence within their tasks show high intrinsic motivation, high task persistence and high self-efficacy beliefs (Zimmerman, 1990; Covington, 2000).

We propose that one way of increasing intentional workplace learning is through promoting workers’ self-regulation by enabling them to consciously embed their learning needs within clearly defined organizational goals. Communicating organizational goals and visions to workers has been proposed as a motivator for revising, reflecting and sharing individual knowledge and competences at workplace (Nonaka & Takeuchi, 1995). Planning one’s learning goals intentionally as part of the projects or tasks that one is responsible for may firstly require that associated organizational and group goals and expected competences be accessible and compared with personal competence profiles. Secondly, seeing that co-workers are proactive as learners in the workplace and being able to monitor their learning process for certain competences can add the motivational component for learning at the workplace.

In our work, we consider SRL in the workplace as a part of organizational learning. In particular, we base our research on a well-known organizational knowledge building model proposed by Nonaka and Takeuchi (1995), which highlights the renewal of organizational level norms and visions based on the generalization of workers’
experience and the guidance which individual workers receive from the organizational knowledge. However, this model does not target the importance of SRL in the workplace as a motivational element for learning and reflecting about learning. Elaborating on the original knowledge building model, Pata & Laanpere (2008) propose that in order to perform intrinsically motivated learning in organizational contexts, learners have to align their learning activities to their organizational learning goals, the learning activities of other members of the organization and their own learning goals. To be able to do this, learners need personalized information – i.e., information relevant to them and their present learning context – about the organization’s objectives and expectations, learning activities and achievements of co-workers and learners’ own progress with regard to their current learning goal(s). However, access to this kind of information is not straightforward as today’s knowledge workers often use diverse tools for their everyday working and learning practices; thus the traces and outcomes of their activities are dispersed among different and often heterogeneous tools. To be turned into information relevant for learners, the traces (i.e., activity data) about learners’ learning activities and created knowledge objects (KOs) have to be structured, organized and well annotated, so that they can be (re-)discovered and (re-)used inside the organization (Siadaty et al., 2010).

To address this challenge, we propose the use of ontologies as they are highly suitable for integrating data originating from different, often dispersed and heterogeneous sources (Allemang & Hendler, 2008). They are, among other things, an excellent means for the integration of: i) traces about individuals’ activities across diverse tools and services, and ii) individuals’ knowledge into shared, organizational knowledge (Jeremic et al., 2009). Specifically, the network of ontologies that we developed within the IntelLEO EU project (IntelLEO D1.4) enables formal representation, and seamless integration of data about individuals’ learning experiences (i.e., learning activities and their context), knowledge being shared as well as different kinds of annotations (tags, comments, ratings and the like) which capture either personal or community reflections on the shared content/knowledge. These ontologies provide the basis for all the functionalities of Learn-B, our tool aimed at scaffolding SRL processes in intentional/non-formal learning in organizational contexts.

In this paper, we first elaborate on the pedagogical foundation of our work and describe the functionalities of Learn-B which support the proposed pedagogical model. Then, the role of ontologies in data integration is explained and exemplified. After presenting the research method in conducting, and the results of the initial evaluation of Learn-B, we conclude the paper by comparing our work to the related work and by outlining directions for further research.

**Pedagogical Framework**

There are a number of models offering alternative perspectives about how learning is self-regulated (e.g., Boekaerts, 1997; Pintrich, 2000; Winne & Hadwin, 1998; Zimmerman, 1989). These perspectives can be categorized into two major sets: one referred to as the “process” perspective and the other one as the “component” perspective to SRL (Dettori & Persico, 2008). SRL in the process perspective is rather goal-oriented: it consists of a set of phases which cyclically repeat during learning activities of self-regulated learners and influence one another. The component perspective, on the other hand, identifies cognitive (behavioural), meta-cognitive, motivational and emotional aspects of (self-regulated) learning and bears a meta-cognitively weighted definition of SRL (Puustinen & Pulkkinen, 2001). Following a process-based perspective, self-regulation has been referred to as the ability to plan, monitor and evaluate one’s own learning processes and strategies (Inoue, 2007). Accordingly, self-regulated learners typically engage in Planning, Monitoring and Reflection processes, where they set their goals and strategic plans; observer their performance and apply appropriate strategy changes; and compare their self-observed performance against some standard, such as one’s prior performance (Jackson et al., 2000; Puustinen & Pulkkinen, 2001).

To gain a better understanding of SRL in workplace, however, some major challenges should be addressed. Firstly, the majority of conventional interpretations of SRL are based on an individualistic perspective (Jackson et al., 2000). Such perspectives contradict the social nature of the workplace, where individuals’ work and learning activities are highly social and community centered. The role of the social context becomes bolder when it comes to defining and evaluating learning goals, adapting one’s strategies to social/organizational norms and receiving incentives or experiencing inhibitors from the communities the learner belongs to. Furthermore, SRL is highly context dependent and the unique features of a learning environment can influence whether or not a learner enacts SRL practices (Boekaerts & Cascallar, 2006; Whipp & Chiarelli, 2005). The contextual nature of workplace learning implies that the organizational context puts an imperative impact on how workplace learning is conducted and the desired goals are achieved.
To address the above stated challenges, in our research we have extended the approach proposed in (Pata & Laanpere, 2008), that is built on Nonaka and Takeuchi’s (1995) knowledge building model, with self-regulatory learning support to promote intentional workplace learning, along with elements to support the social as well as the organizational nature of learning at workplace. Pata & Laanpere’s (2008) elaborated knowledge building model suggests that aligning one’s learning activities with i) organizational normative goals, ii) learning goals and activities of other members in the organization and iii) the individual’s own learning goals enables learners to stay on track and motivates them to engage in learning processes. The extensions to the elaborated knowledge building model, in particular, include i) SRL practices to support individuals in initiating and conducting their learning processes; ii) social embeddedness elements to support the social nature of workplace learning; and iii) support for the harmonization of individual leaning goals with those of the organization to foster the contextual dimension of learning at the workplace. All these extensions play an important role in enhancing the motivation of individuals to take part in learning and knowledge building activities at their workplace. We call this extended pedagogical framework “SRL@Work” and for it to work effectively, we suggest the following proposition and further investigate it within the study presented later in the paper. Accordingly, we hypothesize that providing users with the necessary input from both the social and organizational contexts of their workplace would support them to engage in self-regulatory learning at workplace, specifically, in conducting the planning and monitoring practices of SRL@Work model.

Learn-B: A Semantic Web-based tool implementation of SRL@Work

Via Learn-B, knowledge workers can benefit from recommendations, originating from the organizational and social context of their workplace, to better identify their competence gaps; find the most fitting learning strategies, (extracted from the organizational memory) to reach the missing competences; monitor their learning progress, share and document their learning experiences and, compare their self-observed performances against organizational benchmarks and/or the performance of their colleagues. To illustrate the functionalities of Learn-B from the perspective of the challenges discussed in the Pedagogical Framework and the role of the underlying ontologies, in the following we walk through a typical scenario for workplace learning involving a newcomer in a large organization. A description of the functionalities of Learn-B and the way each of them contributes to supporting our SRL@Work pedagogical framework are given in (Siadaty et al., 2011); technical details about the Lean-B environment are further described in (Siadaty et al, 2012).

Usage Scenario

Brian is a newcomer in a company who plans to start his learning and knowledge building activities at his new workplace. However, like many other newcomers, he is concerned about gaining/enhancing the competences required for the duties assigned to his new organizational position. Our previous research (Siadaty et al., 2010) shows that lack of familiarity with organizational needs, policies and expectations is one of the major challenges that newcomers face in larger companies. Likewise, Brian is not sure wherefrom he can obtain the information about competences related to his new duties. To help Brian start his learning process and plan his learning goals, the Contextual Recommendation of Available Competences feature of Learn-B provides him (under the Duties category) with a ranked list of the competences which are valued by his company and required for accomplishing his duties. Additionally, Brian can benefit from the personalized visual hints that indicate those competences of higher importance for him, considering his current state of expertise with regard to the duties he is responsible for (Figure 1. A).

Having analyzed the organizational requirements and his learning needs, Brian can now set a new learning goal in his Learn-B environment (Figure 1. B), and add the selected competences to it. Next, he needs to obtain information about the best ways to achieve these competences and make his personal plans. For each recommended competence in his Learn-B, Brian can glance over the Recommended Learning Paths, Learning Activities and Knowledge objects for that competence (Figure 1. C), and also explore their Usage Information, such as visual representations showing the number of users, along with their organizational positions, who have been successful in achieving a certain competence by following a recommended learning path, the average time that took other users to complete a recommended learning path, or indicators representing how “live” a learning path has been recently, e.g., the number of comments, rankings, tags, and submitted help requests for it (Figure 1. D). The recommendation of a learning path
is further augmented with the number of users (or organizational roles) who have successfully finished this path or a revision of it, and their average completion times (Figure 1. G). All in all, this information enables Brian to better plan for his learning process and allocate the appropriate resources for achieving his learning goals. Again, the integrated set of ontologies (see The Underlying Ontologies section) is the main enabler for the induction of all this diverse information based on the activities of various users in different working environments.

Once Brian has chosen learning paths for the competences comprising his new learning goal, he can simply follow the selected learning paths toward achieving each competence. At this level, Progress-o-meter enables him to monitor his learning process (Figure 1. E). Further, the updates provided by Social Wave enable Brian to better adapt his learning strategies with regard to the social context of his organization (Figure 1. H). To monitor the extent of sharing his learning experiences within the organization and compare it with that of other users within the same group, project, or the entire organization, Brian can make use of his Knowledge Sharing Profile (Figure 1. F). Having all these activities tracked and gathered in one place is supported by the underlying ontologies, as explained in the following section.

The Underlying Ontologies

Learn-B relies on an interlinked set of ontologies as its common (linked) data model. It provides the ground for the data linking and exchange among the tools integrated in Learn-B. Being developed within the IntelLEO project (http://intelleo.eu/), the ontologies are named after the project. They have been developed by following a combined top-down (review of existing work in the field) and bottom-up (requirements elicitation from IntelLEO business cases) approach. By following the recommended practices in ontology engineering (Allemang & Hendler, 2008) and publishing Linked Data on the Web (Heath & Bizer, 2011), when developing the ontologies we relied on and linked to the vocabularies and ontologies already available and in use. The ontologies are designed to be modular and extensible. Due to space limits, we do not discuss the details of the underlying ontologies, i.e. the IntelLEO ontologies, in this paper. Examples showing how these ontologies support the gathering and integration of various users’ activities could be found in (Siadaty et al., 2011). Also, detailed specifications of all the IntelLEO ontologies are available at: http://goo.gl/gt3cM.
Method

To advance our understanding on how SRL practices are enacted in workplaces, how they can be supported considering the non-formal, contextual and social characteristics of learning at the workplace, and thus to evaluate the integrity and effectiveness of our ensuing SRL@Work pedagogical framework (see the Pedagogical Framework section), we developed the Learn-B environment. However, contrary to what is currently pursued by many researchers in the field (Amiel & Reeves, 2008), the purpose of developing this environment was to “improve”, not to “prove”. Thus, to explore the effect of the provided functionalities we believed they should undergo a continuous cycle of design-reflection-design in close collaboration with practitioners and in the context which they were designed for. In view of that, we followed a Design-based Research (DBR) approach where educational interventions are viewed holistically, i.e., they are evaluated via interactions in real practices (Design-based Research Collective, 2003). Such a contextual perspective helped us to better understand the effect of the designed functionalities and facilitated the assessment of our pedagogical framework.

In this section, we first introduce the research question addressed in this paper, the respective research hypotheses, and the research model (Figure ) we built to investigate our research question and hypotheses. We then describe the main components of the conducted study and the processes used in its preparation and execution.

Research Question and Hypotheses

The study was driven by the following main research question (RQ):

RQ- How do learners perceive the usefulness of various functionalities of Learn-B in performing SRL practices at their workplace?

This research question aimed to examine the general usage beliefs of users about how the different functionalities provided by Learn-B (Siadaty et al., 2011) helped them engage in the three SRL practices, i.e. Planning, Monitoring and Reflection. Based on our pedagogical framework, our a-priori assumptions were as the following:

- **Contextual Recommendation of Available Competences** informs users of the learning needs and expectations of their organization along with the available competences which users can choose from. This helps users to not only harmonize their learning goals with those of their organization, but to better know their learning context and make decisions accordingly. Our a-priori hypothesis is that this functionality supports users in performing the Planning practice, in particular the goal setting/task analysis (hypothesis H1.a) and making personal plans sub-practices (hypothesis H1.b).

- By providing users with information about the available learning paths and knowledge objects for achieving any of the available competences, **Recommendation of Learning Paths, Learning Activities and Knowledge objects** further allows users to get to know their learning context in accordance to the learning objectives of their organization. Our respective assumption here is that this functionality supports users to perform the Planning practice, in particular the goal setting/task analysis (H1.c) and making personal plans sub-practices (H1.d).

- **The Provision of Usage Information** functionality fosters the social embeddedness dimension of workplace learning by letting users know how the other members of their organization have approached their learning goals. Our hypothesis is that such information firstly aids user to get acquainted with their learning context (H1.e) and create their personal plans accordingly (H1.f). Furthermore, it allows users to share their learning experiences with their colleagues when applying any necessary strategy changes, based on the observed usage of learning resources by their colleagues (H1.h).

- **Progress-o-meter** informs users of their progress toward their learning goals and brings their attention into their individual learning progression. Hence, our a-priori hypothesis with regard to this functionality is that it supports users in their Planning phase of their self-regulatory practices; so that users can make/adjust their personal plans according to their own individual progress (H1.g).

We built a research model, shown in Figure 2, to investigate our research question. We investigated this research question by looking into users’ perceptions of the usefulness of the provided support in conducting their SRL processes at their workplace. A specific set of question items were used as indicators of the perceived usefulness of different dimensions of each functionality. These question items are listed in Tables 1, 2 and 3. The SRL practices,
shown in the central part of Figure 2, were manifested via the three tasks that the users performed in the study. The blue dotted arrows represent the RQ and the respective hypotheses in our research model.

![The Support provided via Learn-B](image)

**Figure 2. The applied research model**

**Study Design**

**Design**

The purpose of our study was to evaluate the efficiency of the proposed solution, Learn-B, in supporting non-formal self-regulatory learning at workplace, based on our SRL@Work pedagogical model. We formulated our research question accordingly, and used prototypes of the main functionalities of Learn-B to investigate it.

Due to the empirical nature of our research question, the study was designed with an exploratory focus in that users’ perceptions of the usefulness of Learn-B’s functionalities in conducting SRL practices were to be assessed. In addition, to avoid users getting lost in the Learn-B environment and to support the usage of the functionalities we intended to evaluate in this study without running an extended training session, we used a structured scenario to guide the users through a number of tasks. A detailed description of these tasks is given in the Procedure sub-section. Scenarios, in general, are used to present and situate proposed solutions in the practical context of end-users, and are regarded as a very useful technique to visualize the consequences of the introduction and usage of an innovative technology, tied to practical concerns from the end-users everyday life (Eisma et al., 2003; Carroll, 2000). Last but not least, to advance the existing research knowledge related to supporting SRL in workplaces of different natures, we aimed to have a user study with a sufficiently diverse sample of organizational contexts. With such a sample inherently varied in terms of its data, we were able to analyze the resulting data in the way needed to address our research question.
Participants

An early prototype of Learn-B was evaluated in February 2011 with end-users from three different business cases participating in the IntelLEO project. Thirty users participated in the study: 8 from the first business case of the project (a leading car manufacturer), 12 from the second (an SME) and 10 from the third business case (a teacher professional association). Majority of the participants had university degrees (83.3%). There were 23.3% users with 10 or more years of working experience, 36.7% with 3 to 4 years’ experience, 23.3% with 2 to 3 years, and the rest had less than one year of work experience in their current organizational positions.

Materials

The materials used in the study included: the questionnaires, the Learn-B environment loaded with each business case data separately, and the study scenario tailored to each business case.

To measure users’ usefulness perceptions of the Learn-B’s functionalities, we designed questions targeting the different dimensions of each functionality and included them in a proper section of the questionnaires which the users filled in after each study task. For instance, the Provision of Usage Information functionality was indicated through two dimensions: i) Analytics, including information such as the number of people who worked with/used a specific resource holding the same or related duties/roles as the user, their average completion time, etc. where the details of the provided analytics varied per resource; and ii) Social stand, which reflected what other members of the organization thought about a certain resource, implemented in diverse forms such as keywords, comments and ratings of other users. A description of these questions, the specific functionality that each question manifests, and the learning task (i.e., SRL practice) after which the question was answered are shown in Tables 1, 2 and 3. The questionnaires were comprised of 5-point Likert scale items with values ranging from 1-Strongly Disagree to 5-Strongly Agree for the usefulness of the functionalities items.

We asked participants to perform a series of tasks, described in the learning scenario, using Learn-B. The study scenario was phrased in a manner specific to each target business case, such as “requested by the management” in case of the first business case (i.e., the leading car manufacturer) or “as part of the user’s professional development plan” in the third business case (i.e., the professional teacher association).

Procedure

The study was conducted on site of each business case of the IntelLEO project. The end users were asked to complete a series of learning tasks in the context of a learning scenario, authentic to the specific organizational context of each business case. At the beginning of the study, the participants were familiarized with the study scenario and the included learning tasks. The learning tasks were the same across the business cases, in order to allow for the comparison of results between the three different organizational settings. For instance, all of the participants were asked to create a learning goal based on a set of recommended competences, while these recommended competences differed across the three business cases. Upon completing each task, the participants were asked to fill in the corresponding questionnaire. The tasks are described in the following.

Task 1. In the first task of the learning scenario, the users were asked to create a learning goal in Learn-B, select one or more from the three available organizational competences and include them in their newly created learning goal. Each competence had a specific set of attributes that described it in more details. After finishing this task, the participants were asked about the functionalities that they perceived as useful in performing this task. According to the SRL model that our pedagogical framework is based upon, this task represents the Planning practice, and the “Goal Setting/Task Analysis” step of this practice, in particular.

Task 2. In the second task, the users were requested to browse, select and adapt one of the available learning paths related to the organizational competences from Task 1. The learning paths were accompanied with different information such as users’ comments and ratings, achievement information (e.g. the number of users who already completed a given learning activity in a learning path), and various knowledge object formats (e.g. URL, text documents, videos). After finishing the task, the participants were asked to identify the functionalities that they found
useful when choosing a learning path. By choosing and adapting a learning path for their learning goals, users engaged in the Planning practice of their SRL process, the “Making personal plans” step specifically.

Task 3. In this task, users were asked to add a knowledge object to one of the learning paths chosen in Task 2. The knowledge object was supposed to be defined in the form of an external URL and the participants had to link it to one of the learning activities in the respective learning path, and set its attributes such as visibility, personal rating, tags, etc. After completion of the task, the participants were asked about the functionalities that they found useful when documenting their own learning resources, in terms of user-added knowledge objects. This task represents the Monitoring practice of the SRL@Work model, “Applying appropriate strategy changes” step.

Data Analysis

To examine our research question, we analyzed the questionnaires’ data using descriptive statistics including mean and standard deviation values. Using standard descriptive statistics to analyze the type of the data and research questions we had is a common practice, as reported by Blaikie (2003). Also, it is noteworthy to mention that although there exist two schools of thought on analyzing Likert-scale data i.e., ordinal vs. interval (Carifio & Perla, 2008), we followed the latter. This choice is backed with a significant amount of empirical evidence indicating that Likert scales can be used as interval data (Carifio & Perla, 2008; Carifio, 1987). To gain a summative view over users’ usefulness perceptions, we grouped the responses to question items into “Not-Agree”: Likert-scale responses 1, 2 and 3 and “Agree”: Likert-scale responses 4 and 5.

Results and Discussion

We analyzed the descriptive statistics of the respective questionnaire items, shown in Tables 1, 2 and 3, to examine our research question. The first column in these tables shows the functionality; the second column is the indicator question item as it was presented in the questionnaire; the third column gives the number of users who agreed with the given question item and finally, the fourth column shows the descriptive statistics. For each question, we report the central tendency measure i.e., Mean (M), Standard Deviation (SD) and the number of valid responses (N). In the following, we have organized the presentation and discussion of the results according to each performed SRL (sub-) practice.

Planning: Task Analysis and Goal Setting

H1.a (Figure 1): Results from the users’ answers (Table 1) show that almost all of the users agreed that seeing the available competences within their organization (Q2c) is useful when they are creating their learning goals (M = 4.62, SD = 0.56, 28 out of 29 users), followed by 86% of them considering seeing the available learning paths for a competence (Q3c) another useful functionality when planning their learning goals (i.e., doing Task Analysis). General information about a competence such as its name, description and keywords (Q2g) was acknowledged as useful by 82% of the users (n = 29, M = 4.38, SD = 0.86). More individualized information about a competence such as its priority with regard to the user’s organizational position (Q2d; M = 4.31, SD = 0.81), the pre-requisites for achieving it (Q2f; M = 4.17, SD = 0.81), and its expected level to be acquired by the user (Q2e; M = 4.03, SD = 0.94) were the other factors provided by the Contextual Recommendation of Available Competences which users found useful when planning for their learning goals (86%, 82% and 72% of the users, respectively). These results suggest that users found it important to know about the learning objectives of their organization, as well as their position with regard to these objectives, such as the priority of a certain competence for their organizational role, when planning their own learning goals.

H1.e (Figure 2): Amongst the Usage Information provided, only the comments (Social stand) on a given competence were perceived useful for planning learning goals by a majority of the users (Q1c; M = 4.14, SD = 0.87); however, most of them, 83%, did not agree that having positive comments from the colleagues was the reason for them to choose a given competence (Q1a, M = 2.83, SD = 0.96). In line with the results related to planning their learning goals, a noticeable number of users (76%) also did not agree that being accomplished by many of their
colleagues was a reason for them to include a certain competence in their learning goal (Q1b; M = 3.05, SD = 0.93). The Analytics information (Q1d:) number of users who already achieved a competence (M = 3.10, SD = 1.12) and (Q1e:) their organizational roles (M = 3.28, SD = 1.19) were also mostly not considered as useful – i.e., 66% and 52% of the users, respectively, did not agree with the corresponding questionnaire items. We believe these results indicate that users study the social context of their organization when setting their learning goals; however, this is not the most influencing element for them; other factors such as organizational goals and expectations might play a more central role in how users define and create their learning goals.

Table 1. Descriptive statistics related to RQ - Planning: Task Analysis and Goal Setting.

<table>
<thead>
<tr>
<th>Functionality</th>
<th>Question Description in the questionnaire</th>
<th># of users in agreement</th>
<th>N, Mean, Std Dev.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Provision of Usage Information</td>
<td>Q1a: I selected a specific competence, because it had positive comments from my colleagues. (Median score across all selected competencies.)</td>
<td>5</td>
<td>29, 2.83, 0.957</td>
</tr>
<tr>
<td></td>
<td>Q1b: I selected a specific competence, because many colleagues successfully completed it. (Median score across all selected competencies.)</td>
<td>7</td>
<td>29, 3.05, 0.929</td>
</tr>
<tr>
<td></td>
<td>Q1c: When I plan my personal learning goals, I think it is useful to see comments from my colleagues concerning the competence.</td>
<td>24</td>
<td>29, 4.14, 0.875</td>
</tr>
<tr>
<td></td>
<td>Q1d: When I plan my personal learning goals, I think it is useful to see how many people have already achieved and not yet achieved this competence.</td>
<td>10</td>
<td>29, 3.10, 1.012</td>
</tr>
<tr>
<td></td>
<td>Q1e: When I plan my personal learning goals, I think it is useful to see the role of employees who [have] achieved this competence.</td>
<td>14</td>
<td>29, 3.28, 1.192</td>
</tr>
<tr>
<td>Contextual Recommendation of Available Competences</td>
<td>Q2a: I selected a specific competence, because it was the competence I would need most urgently to increase my job performance. (Median score across all selected competencies.)</td>
<td>21</td>
<td>29, 4.00, 0.973</td>
</tr>
<tr>
<td></td>
<td>Q2b: In general, visual icons beside each available competence help me to pick those competences that fit my immediate learning needs.</td>
<td>11</td>
<td>29, 3.21, 0.940</td>
</tr>
<tr>
<td></td>
<td>Q2c: When I plan my personal learning goals, I think it is useful to see the available competences within my organization.</td>
<td>28</td>
<td>29, 4.62, 0.561</td>
</tr>
<tr>
<td></td>
<td>Q2d: When I plan my personal learning goals, I think it is useful to see the priority of the available competences for my position.</td>
<td>25</td>
<td>29, 4.31, 0.806</td>
</tr>
<tr>
<td></td>
<td>Q2e: When I plan my personal learning goals, I think it is useful to see the expected level of the available competence for my position (low, medium and high level).</td>
<td>21</td>
<td>29, 4.03, 0.944</td>
</tr>
<tr>
<td></td>
<td>Q2f: When I plan my personal learning goals, I think it is useful to see if I have the pre-requisites for an available competence.</td>
<td>24</td>
<td>29, 4.17, 0.805</td>
</tr>
<tr>
<td></td>
<td>Q2g: When I plan my personal learning goals, I think it is useful to see name, description and keywords of a competence.</td>
<td>24</td>
<td>29, 4.38, 0.862</td>
</tr>
<tr>
<td>Recommendation of Learning Paths, Learning Activities and Knowledge objects</td>
<td>Q3a: I selected a specific competence, because... it had many available Learning Paths. (Median score across all selected competencies.)</td>
<td>16</td>
<td>29, 3.55, 1.055</td>
</tr>
<tr>
<td></td>
<td>Q3b: Seeing all the available and recommended learning paths for each competence help me better make a decision whether to choose a competence or not.</td>
<td>22</td>
<td>29, 3.93, 0.753</td>
</tr>
<tr>
<td></td>
<td>Q3c: When I plan my personal learning goals, I think it is useful...to see the available learning paths for a competence.</td>
<td>25</td>
<td>29, 4.31, 0.806</td>
</tr>
</tbody>
</table>

In line with the above results, when it comes to setting their goal(s) and choosing competences to include in them, 72% of the users agreed that they picked those competences that they needed most urgently to increase their job performance (Q2a); however, only 38% of the users agreed that the visual icons accompanying available
competences helped them to specifically choose the competences that fit their immediate learning needs (Q2b; M = 3.21, SD = 0.904) – H1.a. This might have been due to the unfamiliar design and lower graphical resolution of the icons. Seeing all the available and recommended learning paths (Q3b) was another factor highly acknowledged as useful, by 76% of the users (M = 3.93, SD = 0.75), for choosing a specific competence; further endorsed by over half of the users who agreed that they chose a given competence because it had many learning paths available (Q3a) – H1.c.

Planning: Making Personal Plans

Having analysed the learning context and set their learning goals, the users were prompted to choose a learning path in Task 2 (i.e., perform the “Making Personal Plans” SRL@Work practice). The users’ responses to the respective questionnaire indicate that almost all of the users (96%) agreed that seeing all the matching available learning paths and their included learning activities and knowledge objects (Q7a) is useful when they want to choose a learning path (M = 4.44, SD = 0.583, 24 out of 25 users) – H1.d (Figure ). Seeing their personal progress in completing a learning activity (Progress-o-meters, Q5a), was the other functionality perceived noticeably useful by the users when choosing their learning paths (n = 25, M = 3.88, SD = 1.09) – H1.g in Figure 2.

<table>
<thead>
<tr>
<th>Functionality</th>
<th>Question Description in the questionnaire</th>
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<th>N, Mean, Std Dev</th>
</tr>
</thead>
<tbody>
<tr>
<td>Provision of Usage Information</td>
<td>Q4a: I perceive the following functions as useful, when I have to select my learning path…to see my colleagues' rating of a learning activity or document.</td>
<td>15</td>
<td>25, 3.60, 0.764</td>
</tr>
<tr>
<td></td>
<td>Q4b: I perceive the following functions as useful, when I have to select my learning path…to see the keywords of a learning activity or document.</td>
<td>16</td>
<td>25, 3.68, 0.900</td>
</tr>
<tr>
<td></td>
<td>Q4c: I perceive the following functions as useful, when I have to select my learning path…to see the comments of my colleagues concerning the learning activity or document.</td>
<td>18</td>
<td>25, 4.00, 0.764</td>
</tr>
<tr>
<td></td>
<td>Q4d: I perceive the following functions as useful, when I have to select my learning path…to see how many people completed the activity or are still actively involved it.</td>
<td>9</td>
<td>25, 3.00, 1.19</td>
</tr>
<tr>
<td></td>
<td>Q4e: I selected a specific learning path, because the learning activities and documents had positive comments from my colleagues.</td>
<td>9</td>
<td>25, 3.24, 0.831</td>
</tr>
<tr>
<td></td>
<td>Q4f: I perceive the following functions as useful, when I have to select my learning path…to see the roles of the colleagues, who finished this learning activity.</td>
<td>9</td>
<td>25, 3.00, 1.155</td>
</tr>
<tr>
<td></td>
<td>Q4g: I selected a specific learning path, because many colleagues were and still are involved with the related learning activity.</td>
<td>7</td>
<td>25, 2.92, 0.997</td>
</tr>
<tr>
<td></td>
<td>Q4h: I selected a specific learning path, because... the learning activities and documents had a good rating from my colleagues.</td>
<td>7</td>
<td>25, 3.04, 0.841</td>
</tr>
<tr>
<td>Progress-o-meters</td>
<td>Q5a: I perceive the following functions as useful, when I have to select my learning path … to see my personal progress for a learning activity.</td>
<td>18</td>
<td>25, 3.88, 1.092</td>
</tr>
<tr>
<td>Recommending Available Competences</td>
<td>Q6a: I selected a specific learning path, because the related learning activities and documents had a good and clear description.</td>
<td>12</td>
<td>25, 3.48, 1.085</td>
</tr>
<tr>
<td>Recommendation of LPs, LAs and KOs</td>
<td>Q7a: I perceive the following functions as useful, when I have to select my learning path… to see the available learning paths, learning activities and documents within my organization.</td>
<td>24</td>
<td>25, 4.44, 0.583</td>
</tr>
</tbody>
</table>

In addition to the keywords accompanying learning activities/documents a learning path is composed of (Q4b), colleagues’ ratings of (Q4a) and their comments about these resources (Q4c) were the other Usage Information - Social Stand which users majorly found useful when making their personal plans; H1.f in Figure 2 (M = 3.68, SD = 0.764).
When asked about the reasons on why they chose a certain learning path, good and clear descriptions of the respective activities and documents (Q6a) were the only functions perceived useful by nearly half of the user (M = 3.48, SD = 1.08) – H1.b. Similar to the results for when setting their learning goals, most of the users did not agree that positive comments (Q4e) or high ratings (Q4h) from the colleagues were necessarily the reasons for them to choose a given learning path (M = 3.24, SD = 0.831; M = 3.04, SD = 0.841, respectively). Likewise, neither being completed by many of their colleagues (Q4g), nor knowing the number of colleagues involved with/working on a learning activity (Q4d) were considered as the reasons to choose a learning path by a good number of the participants, (M = 2.92, SD = 0.997; M = 3.00, SD = 1.190, respectively). This indicates that users prefer to know clearly what options their organization is offering them, rather than merely relying on the achievement information or performance of their colleagues. Such results could be indicative of a poor organizational culture that does not nurture trust among employees. However, this is an early assumption and certainly requires further investigation.

Table 3. Descriptive statistics related to RQ – Monitoring: Applying appropriate Strategy Changes.

<table>
<thead>
<tr>
<th>Functionality</th>
<th>Question Description in the questionnaire</th>
<th># of users in agreement</th>
<th>N, Mean, Std Dev</th>
</tr>
</thead>
<tbody>
<tr>
<td>Provision of Usage Information</td>
<td>Q8a: When I want to document my own learning resources, I think it is useful...to add keywords.</td>
<td>19</td>
<td>24, 4.13, 1.274</td>
</tr>
<tr>
<td></td>
<td>Q8b: When I want to document my own learning resources, I think it is useful...to allow the rating of my new knowledge asset.</td>
<td>15</td>
<td>24, 3.67, 1.007</td>
</tr>
<tr>
<td></td>
<td>Q8c: When I want to document my own learning resources, I think it is useful...to set the visibility of my learning activity and document.</td>
<td>19</td>
<td>24, 4.13, 0.741</td>
</tr>
</tbody>
</table>

Related Work and Conclusions

Different approaches to supporting individuals’ active participation in learning and knowledge building activities at workplace have been the subject of several research efforts recently. The main focus of the APOSTDLE project was on supporting individual workplace learning, making employees aware of the available knowledge sources for a task at hand (Lindstaedt & Mayer, 2006), while harmonization of individual and organizational learning and the effect of the social nature of workplace on learning were not addressed.

To provide the required support for the knowledge maturing process, the MATURE project relied on the semantically-empowered social software tools such as semantic wikis and semantic social bookmarking tools. Whereas this project gave a significant contribution to understanding and supporting the (knowledge) maturing
model (Maier & Schmidt, 2007) as an organizationally-guided learning process, the importance of SRL and social-embeddedness in workplace learning were not investigated.

The central component of the TENCompetence EU project (Koper & Specht, 2008) is Personal Competence Manager which supports users in identifying their competence gaps, choosing the appropriate learning paths towards the achievement of the missing competences and directing them to the appropriate learning resources (Kew, 2007). Obviously, this software solution bears a lot of similarities to Learn-B; however, we believe that we have made a step forward by introducing a framework for motivating intentional/non-formal workplace learning.

Being based on the SLATES framework (McAfee, 2006), the OrganiK project is oriented primarily toward supporting knowledge management in organizations through combining elements from the domains of Enterprise 2.0 and Semantic Web technologies (Bibikas et al., 2008), whereas less attention is paid to workplace learning.

The ARISTOTELE project (ARISTOTELE Project) aims to support the creation and further strengthening of a connection between organizations’ learning strategies and real learning needs of its employees. Even though the research work of this project bears resemblance to our work presented in this paper, it seems to be missing an import component our approach is based upon – motivational framework for workplace learning.

As advancement to the abovementioned research initiatives, in this paper we have proposed a novel pedagogical framework, named SRL@Work, that extends the traditional model of SRL with elements originating from and necessitated by the social and organizational context of workplace learning. Most importantly, SRL@Work argues for the alignment of one’s SRL practices with their own learning goals, learning goals of other organizational members, and the organization’s learning goals. Aiming to assess the validity and effectiveness of the proposed pedagogical framework, we have developed Learn-B as our research prototype following the Design-based Research approach. With Learn-B, we organized an empirical study to evaluate the main propositions of the SRL@Work pedagogical framework and to gather users’ feedback that would help us rethink and improve the design of both the proposed framework and the software prototype. As shown in the previous section, the study results do support the main propositions of our SRL@Work model, though further exploration of some observed issues is needed. For instance, we found that users did not heavily draw on the social context (e.g., other users’ comments and ratings, and achievement information) when making their learning plans. This could have been caused by the unfamiliar look and design of some of the Learn-B’s features (such as the visual indicators and charts) aimed at communicating information originating from the social context, but it could also indicate that the organizational culture that does not nurture trust among employees. This and other early assumptions, derived from the study results and stated in the previous section, need further investigation which we intend to do as a part of our future work. In fact, we have just finished a more comprehensive user study based on a combination of quantitative and qualitative evaluation methods. It is our belief that the data collected in this study, will help us obtain deeper empirical insights into the unresolved issues and bring us some new insights about employing self-regulatory practices in the context of workplace learning. In parallel with the analysis of the collected data, we intend to work further on the development of Learn-B and in particular improvement of its support for documenting and sharing learning experiences, and collaborative learning.

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References


Youth as Design Partners: Age-Appropriate Websites for Middle and High School Students

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ABSTRACT

This study explored the impact of using best practices identified in previous studies in designing age-appropriate websites for middle and high school youth. Utilizing a mixed-method approach, 31 middle and 22 high school youth took part in six focus groups across four states. Participants were introduced to a website specifically designed for either middle or high school youth, asked to discuss their overall opinions of content and interface design, and then asked to rate their overall first impressions of the site. Satisfaction ratings for both groups increased for each design iteration (high school from 6.2 to 8.0; middle school from 6.7 to 8.25) and the results validate previous findings that unique differences exist between middle and high school user preferences. Chi-Square tests (p=.05) suggest middle school website ratings increased significantly while high school website ratings, which improved, remained inconclusive. The implications of the study include a youth website design checklist for both middle and high school youth and the introduction of a new construct, concept actualization, which reflects the need for designers to shift from adult to youth oriented paradigms when designing digital environments through close collaboration between adult and youth designers.

Keywords

Age-appropriate web design, Youth information seeking, Youth digital environments, Web design, Iterative design

Introduction

One of the principle web design challenges is designing an interface and information architecture that presents information to different user groups on an appropriate cognitive and affective level. In the fast-paced world of information seeking on the Web, designers have only 25-35 seconds to capture and engage a user’s attention (Nielsen & Loranger, 2006). While there are design guidelines to increase the likelihood that a user will find a site engaging, designing age-appropriate websites for youth is uniquely challenging because site developers are typically adults far removed from the perspective of the youth age-group they are trying to reach. As Scaife and Rogers (1999) note, “Kids are aware of aspects of the use of technology that we [adults] are not sensitive to and that we need to be told of” (Large, Beheshti, & Rahman, 2002, p. 79).

Children of today, born after the emergence of the Internet, are considered millenials (Considine, Horton, & Moorman, 2009) that have been born digital and raised as “Digital Natives” (Margaryan, Littlejohn, & Vojić, 2011; Prensky, 2001). Everyone else can be considered digital immigrants and, “As educators, we need to be thinking about how to teach both Legacy and Future content in the language of the Digital Natives” (Prensky, 2001, p. 4). According to Prensky (2009), the pervasiveness of digital devices and environments in our day-to-day lives coalesce into a digital wisdom characterized by two major facets: “He or she accepts digital enhancement as an integral fact of human existence, and he or she is digitally wise, both in the considered way he or she accesses the power of digital enhancements to complement innate abilities and in the way in which he or she uses enhancements to facilitate wiser decision making” (Prensky, 2009, p. 3-4).

Technology is a ubiquitous presence and as much a part of daily life for most children as going outside to play, riding their bike, or reading a book. It offers opportunities for exploration, interaction, and social collaboration. In fact, a recent 2011 study found that 97% of all virtual accounts are registered to users 25 years or younger and that 22% are age 5-10 and 46% are age 10-15 (Chow & Bucknall, 2011). Seventy-seven percent of all US households have Internet access (Internet World Stats, 2010); 92.3% of K-12 students use a computer at school (US Census Bureau, 2003) and over 77% of households with children ages 6-17 have Internet access (US Census Bureau, 2009).
Being a Digital Native, however, is not synonymous with information seeking expertise as, “their extensive use of ICT often creates a false sense of competency, as well as the misperception among many adults that contemporary youth are “media savvy.” Hands on is not the same as heads on” (Considine & Horton, 2009, p. 472). While there is a growing body of literature on the cognitive, affective, and information seeking habits of children and adolescents, there is a scarcity of research on how to apply this information to the design of information portals for youth that are increasingly proliferating the web for social, educational, and entertainment purposes.

**Theoretical framework**

One of the greatest challenges for educators today is negotiating effectively the paradox of utilizing a workforce of digital immigrants or teachers who have not grown up with technology (Margaryan, Littlejohn, & Vojt, 2011) teaching a generation of youth who are Digital Natives, those who have grown up with access to the Internet and a wide array of information and communication technologies (ICTs) (Considine, Horton, & Moorman, 2009). Social interaction and communication appears to be a key component in this paradox. Schools frequently ban social networking sites like Facebook, MySpace, and YouTube and restrict the Internet in general, failing to realize that these technologies are not only mere environments for play but also a fundamental way in which today’s youth communicate, think, express themselves, and contribute and receive information. Such a disconnect represents an unexplored pathway to potentially vibrant resonance between educator and student: “If there is a crisis in today’s schools, it probably has more to do with students’ perceptions that school is boring and largely irrelevant to preparation for life outside school” (Considine, Horton, & Moorman, 2009, p. 473; National School Boards Association, 2007; Prensky, 2008a). Prensky (2008a) refers to much of the content being taught in today’s schools as a “backup education”—content and knowledge of the past that is largely disconnected from preparation for the future. This educational paradigm paradox between Digital Immigrants attempting to prepare Digital Natives for a future in a digital world posts a seminal question to all educators: “What will serve our kids better in 20 years—memorized multiplication tables or fundamental knowledge of programming concepts? Long division algorithms or the ability to think logically and to estimate? The ability to write cursive handwriting or the ability to create meaningfully in multimedia?” (Prensky, 2008b, p. 3).

A paradigm shift is necessary for adult educators and information designers to understand the dynamics of this paradox; that spaces intended for youth must incorporate their unique, developing perspectives, values, and likes/dislikes. In order to design age-appropriate information spaces for youth it is critical to understand how they seek and process information and to what extent these differ from adults. Current literature suggests pronounced differences in information seeking behavior amongst adult users, high school students, and middle school students (Blowers & Bryan, 2004; Buckleitner, 2008; Cai & Zhao, 2010; Considine, Horton, & Moorman, 2009; Cooper, 2005; Large & Beheshti, 2005; Nielsen, 2005). For the purposes of this study, research on the similarities and differences between high school age users (15 to 18 years) and middle school age users (11 to 14 years) will be explored in order to conceptualize websites that meet the divergent needs, perspectives, and expectations of youth information seekers.

**Children and adolescent web information seeking behavior: Age-specific cognitive and affective states**

Blowers and Bryan (2004) define “children” as four discrete groups based on reading ability: pre-readers (age 3-5), beginning readers (age 5-8), intermediate readers (preteens age 9-12), and teen readers (age 13-17) (Dubroy, 2010). Piaget’s theory of cognitive development represents a useful framework from which to understand children and adolescent cognitive abilities (Huiett & Hummel, 2003). Children younger than three are typically in Piaget’s sensory motor stage where taste, touch, and motor coordination are the major cognitive challenges and therefore children in this age group are not likely to be able to use computers effectively (Cooper, 2005; Haugland, 2000). Children in the pre-reader (age 3-5) and beginning reader (age 5-8) groups are in preschool and early primary school. They considered to be in Piaget’s pre-operational stage where ego-centrism is the primary lens in which the world is perceived (Huiett & Hummel, 2003) and “they are individualistic, self-centered, and expect others to have their perspective” (Cooper, 2005, p. 288). Intermediate, preteen readers (age 9-12) are in the concrete operational stage where “intelligence is demonstrated through logical and systematic manipulation of symbols related to concrete objects” (Huiett & Hummel, 2003). Trial-and-error with physical not abstract objects is how children of this age understand the world and in the digital environment a “… list of alphabet citations may mean much less to children
at this level than an electronic display of familiar book covers” (Cooper, 2005, p. 288). Adolescent teen readers (age 13-17) are in the formal operational stage where intelligence matures to a “…logical use of symbols related to abstract concepts” (Huitt & Hummel, 2003). Information seekers of this age represent emerging adults who reflect similar adult information seeking behaviors.

Information processing research has found that children vary in their cognitive ability to store and retrieve information based on their age driven by two central information processing deficiencies—production and meditational (Cai & Zhao, 2010). Production deficiencies reflect a child’s inability to utilize appropriate storage and retrieval strategies without external prompts; meditational deficiencies refer to a children’s inability to implement effectively storage and retrieval strategies even if prompted (Cai & Zhao, 2010). Children younger than seven years old are considered to suffer from meditational deficiencies and are referred to as “limited processors” while children between seven and eleven years of age are considered “cued processors” that suffer from production deficiencies and are unable to process information effectively without explicit cues. Older children (around 12 and older) usually no longer have these cognitive deficiencies and are called “strategic processors.” (Cai & Zhao, 2010)

Children over six begin to develop more advanced technological and cognitive skills—they start to understand digital avatars represent characters they can take care of and become friends with. Their overall tolerance threshold is higher; they tend to still follow rules explicitly, and in general are more skilled with the computer, mouse, and userids and passwords (Buckleitner, 2008).

Adolescent information seeking (14-18)

Research studies have found that children’s information-seeking behavior is largely defined by browsing rather than specific keyword searches (Large, Beheshti, Clement, Tabatabae, & Yin Tarn, 2009). A typical high school aged information seeker (14-18 years old) has a short attention span, is easily bored, prefers scanning material quickly instead of reading (Fidel et al, 1999), and similar to adults, prefers larger font sizes (DiMichele, 2007; Nielsen, 2005). One research study found that “…students rarely progressed in a linear search, but instead would repeatedly return to a “landmark” page, a finding supported by Wallace, Kupperman, Krajcik, and Soloway (2000)” (Large, Beheshti, & Rahman, 2002, p. 80). Because older children have higher order cognitive abilities, their information seeking behavior are similar to adults—“They can, under the right conditions, apply a wide repertoire of decision-making strategies, quickly eliminate alternatives, and focus their attention on information central to achieving their goal” (Rose, Rose, & Blodgett, 2009, p. 6).

Youth information seekers will tend to gravitate to sites that are easy-to-use, have clean designs with “cool” graphics, and contain interactive features such as online quizzes, voting, and games; of particular interest are web 2.0 technologies that allow for social expression and interactivity with others through on-line forums, message boards, and Wikis (DiMichele, 2007; Nielsen, 2005). Youth information seekers enjoy vivid photographs that engage their attention and interest (DiMichele, 2007) and prefer scanning a site’s graphics for visual cues that allows them to determine at a glance, a site’s perceived relevance and quality of information (Fidel et al., 1999). Typical “distractions,” such as moving images or scrolling information, are usually disdainfully ignored. When there is a need to obtain directions or instructions, the student’s preference is to receive them as illustrations instead of text (Milligan & Murdock, 1996) and, when text is necessary, they favor concise information in large font.

When exploring websites, youth tend to be repelled by sites with visual designs perceived as “kid” focused including childish content, images, or color schemes (Nielsen, 2005). They may also become quickly frustrated with problems resulting from Internet related issues that impede searches such as sluggish web responses, slow downloading sites, and sites which are under construction, as well as human errors such as spelling mistakes and incorrect URLs (Fidel et al., 1999). Not surprisingly, the “back” button is used frequently as a fundamental search feature and is often considered a safeguard when the student gets lost (Fidel et al., 1999).

Although youth are willing to scroll to access information, it is not preferred. If scrolling side-to-side is required, it most likely will not occur (DiMichele, 2007) and information below the “fold” on a computer monitor that can only be found by scrolling down the screen, will largely remain unseen as they move onto other sites. Information is primarily found by moving quickly from one website to another (Fidel et al., 1999).
Pre-adolescent information seeking (10-13)

The typical middle school information seeker (10-13 years of age) shares some similarities with a high school counterpart, preferring visual cues to text and not liking to scroll. The primary information goal, however, resides more with interest and exploration than identification and access to a specific information goal. The middle school student needs bright and engaging colors that attract attention and keeps him or her interested (Large, Beheshti, & Rahman, 2002). Sites that are most appealing are found to be visually pleasing and usually include the use of animation, sound effects (Neilson, 2005), and bright colors throughout the background and the foreground of the site. Middle school students also like creative and significant icons, easily remembered URLs, and well thought-out portal names (Large et al., 2002). They also prefer browsing to searching; only reverting to another approach when information cannot be easily found (Large, Beheshti, Nesset, & Bowler, 2006).

This age group shows a general dislike for scrolling and has a preference for subject categories that can be browsed for more rapid information retrieval. As with high school web users, they do not readily employ help features such as spell-check and become easily frustrated by a lack of immediate success in retrieving desired information. This frustration may be caused by misspellings, resulting in unsuccessful searches (Large et al., 2006) as well as a lack of skill and an underdeveloped knowledge of the use of search engines (Bilal, 2002).

Interestingly, preference for animation depends on the website and information-seeking goals. While middle school students, especially those under 12 years of age, really enjoy animation (Nielsen, 2005) and graphics, they can become irritated when it distracts from the information seeking process (Cooke, 1999; Sullivan, Norris, Peet, & Soloway, 2000). When they enter high school, there is a heightened disdain for animation that distracts from general scanning of information.

Age-appropriate web design for children and adolescents

Contrary to common belief, although high school students may be well-versed in the use of iPods and iPhones and may have grown up utilizing computer technology, surfing the Internet, and texting, they are not “techno-wizards” who intuitively and expertly understand how to navigate the Internet for information seeking purposes (DiMichele, 2007; Nielsen, 2005). A study conducted by the British Library found that while the, “Google generation” could access materials, their ability to process those texts was somewhat limited. Online search strategies of this age group are characterized as “skimming and squirreling behavior” (Considine, Horton, & Moorman, 2009, p. 475). The report concluded that today’s youth did not have a strong understanding of their own information needs, had difficulty utilizing effective information seeking strategies, and spent little time processing whether the information they found was either accurate, relevant, or from a trusted source (Considine, Horton, & Moorman, 2009).

There is a growing body of knowledge about designing youth oriented websites (Cooper, 2005; Druin et al., 1999; Harding, Szakacs, & Parry, 2009; Large et al., 2004, 2005, 2007; Taxen et al., 2001). Some design methodologies include Druin et al.’s (1999) cooperative inquiry, Read et al.’s (2002) participatory design, and Large et al.’s (2006) bonded design (see Harding et al., 2009). Cooper (2005) suggests that a youth website should emphasize user control, be open-ended (encouraging exploration), active (as opposed to passive), involve multiple senses, offer quick feedback, balance novelty with familiarity, allow for and be responsive to child input, allow for progressive levels of expertise facilitating competence while offering new challenges, and support social interaction (Appel & O’Cara, 2001; Cooper, 2005; Clements & Samara, 2003; Davidson & Wright, 1994; Haugland, 2000; NAEYC, 1996; Van Scoter, Ellis, & Railsback, 2001).

Websites for children should be “colorful, relevant, and easy-to-use” (Dubroy, 2010, p. 213). While animation and interactivity are important care must be given to ensuring its use is not “gratuitous” and that “bells and whistles are useless if the content is irrelevant (Blowers & Bryan, 2004). Design should be simple and easy to navigate; in a study of 55 children, Nielsen (2002) actually found that children tended to have an easier time navigating websites for adults rather than children because children’s sites oftentimes are “convoluted” (Dubroy, 2010).

The use of metaphors and help features are important website elements that can help reduce cognitive load for children; metaphors help scaffold new information being presented to preexisting mental structures and images.
Help features have been found to be extremely important to children (Bilal, 2005; Nielsen, 2005). Figure 1 summarizes and compares some of the major differences between younger groups and adult information seekers.

Figure 1. Nielsen’s web design table across users

<table>
<thead>
<tr>
<th></th>
<th>Animation and sound effects</th>
<th>Mine sweeping for links</th>
<th>Advertising</th>
<th>Scrolling</th>
<th>Reading</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kids</td>
<td>☺</td>
<td>☹</td>
<td>☺</td>
<td>☹</td>
<td>☹</td>
</tr>
<tr>
<td>Teens</td>
<td>☹</td>
<td>☹</td>
<td>☹</td>
<td>☹</td>
<td>☹</td>
</tr>
<tr>
<td>Adults</td>
<td>☹</td>
<td>☹</td>
<td>☹</td>
<td>☹</td>
<td>☹</td>
</tr>
</tbody>
</table>

Key:

☺ Enjoyable, interesting, and appealing, or users can easily adjust to it.

☹ Users might appreciate it to some extent, but overuse can be problematic.

☹☹ Users dislike it, don’t do it, or find it difficult to operate.

Source: Nielsen, 2005

As differences between youth and adult information seeking needs are made clearer through research, there is a need for a design model to help guide designers and developers of youth oriented online resources. Druin’s (2002) youth design model, although it does not specifically address teenagers, suggests that, see Figure 2, representative users should be part of the design team from the very beginning, serving multiple roles through the design and development cycle as it evolves (Druin, 2002).

Figure 2. Including children in the web design process in multiple ways (Druin, 2002)

While Druin’s model provides a general framework for how to ensure youth are included throughout the design cycle, more specific guidelines and a roadmap for how to properly include youth in the design and development process is needed.

Purpose and rationale

The purpose of our study was to answer three primary research questions:

RQ1: How do you design a website for diverse populations spanning middle school to high school users?
RQ2: Do middle school and high school students have different information needs?
RQ3: What are the “best practices” for websites designed for middle and high school youth?
The significance of the study rests on a recommended web design model informed by both existing literature and feedback from a wide distribution of high school and middle school students, spanning four different states over a four-year period. Although there are clear suggestions that differences exist between middle school, high school, and adult information seekers, previous research has not provided clear guidelines for how to consider these differences in designing and developing age-appropriate websites properly aligned to directly meet the unique needs of these users.

Method

The study used a mixed-method design involving a case study supplemented by focus groups and hard copy surveys.

Sampling

All participants were samples of convenience in close proximity to participating STARS Alliance universities in Georgia, Tennessee, North Carolina, and Florida. The study’s sample was comprised of 53 high school and middle school participants who took part in six different focus groups: three with middle school students (n=7, n=21, n=3) and three with high school students (n=6, n=12, n=4). Participants in the third set of focus groups were organized into advisory groups that reevaluated their websites two additional times. Demographically, participants were 70% female and 30% male and 66% white (n=35), 25% African American or Black (n=13), 8% Multi-racial (n=4), and 2% Asian (n=1).

Procedures and instrumentation

Pre/post focus group survey

Each participant attended a focus group and completed a 12-item survey divided into four sections: demographic information (Q1-Q4), thoughts on careers in computing and information technology (Q5-Q8), future careers (Q9), and general website feedback including information that they would like to see presented (Q10-Q12). The first three sections of the instrument were completed before the focus group and the fourth section covering website feedback was completed after the focus group.

Focus group questions

Students were shown a web page specifically designed for either middle school or high school students and a series of 13 focus group questions were asked focusing on general reactions to the home page, color, and graphics (Q1-Q7) and what content they would prefer from a site designed to introduce careers in computing and information technology (Q8-Q11). The final two questions focused on what youth their age considered “cool” or “in style” (Q12) and the most important factors when considering future careers (Q13).

Data collection and analysis

To protect against threats to the study’s internal validity all participants completed the same survey. Utilizing SPSS v20 cross tabulations for all six groups were conducted which identified group descriptive statistics such as means, standard deviations, and range. The overall Pearson Chi-square, a non-parametric statistic used because participants were not selected randomly, was statistically significant at the .05 level suggesting that the group web ratings differed enough to be from different populations.

Results

First iteration of middle and high school channels

As part of the design process focus groups were conducted with high school students in three different states. Because the initial high school site was not ready prior to first focus group, they were asked to assess the alpha
version of the middle school test site, which emphasized the use of bright colors and images intended for a middle school-age user.

![Middle school test site v.1](image)

**Figure 3. Middle school test site v.1**

Overall satisfaction ratings were low (M=5.8, SD=1.72) on a 10-point scale (1 lowest, 10 highest). The students liked the banner and the pictures but disliked the overall color and coordination of colors and graphics.

The second high school focus group used the first iteration alpha version of a high school website (v.1). The site was rated slightly higher (M=6.2, SD=2.62) than the first test. Students liked the ability to play music on the site and the overall access to information. Conversely, they found the site was generally “boring” and needed more “wow” colors and interactivity.

![High school channel mock-up v.1](image)

**Figure 4. High school channel mock-up v.1**

---

**Did Ya Know???

- 1.5 million jobs by 2014!
- Average salary over $40,000 year!
- Diverse, exciting, high paying AND beneficial to society!

---

**Computing & IT Fields**

- Computer Engineering >>
- Computer Science >>
- Information Systems >>
- Information Technology >>
- Software Engineering >>

---

**Drive into Your Future!**
The middle school site followed a similar iterative design path. The initial middle school focus group \( (n=7) \) was a full point higher \( (M=6.7, \ SD=.756) \) than the high school group. They liked the colors and graphics but disliked the density of the information, the organization, and the colors, which they felt “did not go well together.” Based on this feedback, the color coordination was refined and new graphics were added, representing a beta version .5.

![Figure 5. Revised middle school channel v.5](image)

After refining the site’s colors and adding additional images, the site was retested with two additional middle school focus groups. The first group was comprised of 7th grade girls \( (n=16) \) and their mean rating unexpectedly was 2.5 points lower \( (M=4.2, \ SD=1.24) \) than the initial focus group ratings. They found that although the information was good, the new color scheme was dull and they complained of the lack of interaction or use of multi-media. Another middle school group was comprised of 8th grade boys \( (n=5) \) and the site also received low ratings \( (M=4.4, \ SD=1.25) \). They liked the information and personal testimonials, but also cited the color and overall “dullness” of the site as major concerns.

**Second design iteration of middle and high school channels—Youth as design partners**

The design team revisited the literature to identify major design flaws behind the beta versions. What became clear is that neither the pervasive usability design process nor Druin’s (1999) child design model, which suggested youth must be design partners from the very beginning stages of design and development, were accurately implemented. As a result, three middle school students and four high school students were brought on as design partners to help redesign both youth sites.

The high school student advisors found the design was “too mature looking,” “too professional” in appearance, used “dull colors,” and too boring. Reviewing best practices identified from the literature, major elements were absent. A checklist comprised of best practices (see Tables 1 and 2 below) was created and design elements were identified in collaboration with the youth design partners. With their input, interactive features such as mouse over rollovers, a blog, and links to several online job assessment quizzes were added.

The new high school design received increasingly higher ratings over three design iterations: \( M = 6.75 \ (SD = .957) \), \( M = 7.1 \ (SD = .629) \), and \( M = 8.0 \ (SD = .500) \), respectively, a full 2.0 points higher than the previous focus group ratings. Chi-Square analyses, \( \chi^2 (4, \ N = 26) = 12.92, \ p = .059 \), however, found that the null hypothesis could not be rejected at the .05 threshold, which suggests that the differences in ratings may have occurred by chance and were not statistically significant.
Students thought the site was “professional,” “clean cut,” “attractive,” and incorporated effective graphics. They did find, however, there was a lack of clarity in terms of the site’s purpose and a need for more color. Revisiting the table of best practices, three of the four factors were present in the new design: interactivity and social networking, graphics emphasizing photographs along with a clean “uncluttered” design, and limited text for easy scanning.

*Table 1. Comparing redesign to best practices for high school students*

<table>
<thead>
<tr>
<th>Recommendation</th>
<th>Does our site have this?</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Easily bored; liked interactivity such as online quizzes, voting, and games; sharing activities such as forums, message boards, and wikis (Nielsen, 2005)</td>
<td>Yes</td>
<td>We added online quizzes and assessments as well as a blog</td>
</tr>
<tr>
<td>Preferred illustrations to text instruction (Milligan &amp; Murdock, 1996)</td>
<td>No</td>
<td>We are still mainly text based</td>
</tr>
<tr>
<td>Cool graphics and clean designs (Nielsen, 2005)</td>
<td>Yes</td>
<td>Overall design tested clean and organized and students liked it</td>
</tr>
<tr>
<td>Like to scan not read (Nielsen, 2005)</td>
<td>Yes</td>
<td>Overall design is more “scanable”</td>
</tr>
</tbody>
</table>
A similar process for the middle school student advisory group was followed. They initially rated the site a 6.0 (SD= .707) and found problems with layout, color, and identified a need for interaction. Analysis of the site compared to middle school best practices found that the design was lacking the primary best practices identified by the literature. Utilizing a best practices checklist and the feedback of the middle school design partners, the colors were refined, animations and sound effects were added, and the site was renamed simply “MSZ” (acronym for Middle School Zone). The next two iterations were rated much higher: \( M = 7.5 \) (SD = .707) and \( M = 8.3 \) (SD = .354), a full 3.7 points higher than the previous focus group and 2.0 points higher than the design group’s initial rating. The design group liked the new colors, the access to real stories of computing and information professionals, and the various interactivity and animation. A Chi-Square test, \( \chi^2 (4, N = 34) = 39.82, p = .00 \), found that the null hypothesis could be rejected at the .05 threshold, which means these differences in overall ratings were different enough to be statistically significant and suggest they came from different populations.

Reexamining the site design by utilizing the best practices table suggested three of the four factors were now appropriately implemented.

Table 2. Comparing redesign to literature best practices for middle school students

<table>
<thead>
<tr>
<th>Recommendation</th>
<th>Does Our Site Have This?</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Colors need to be bright and engaging (Large et al., 2006; Schaller et al., 2004)</td>
<td>Yes</td>
<td>“Engaging” and “bright” colors are of course subjective; after testing with our new design partners we improved in this area</td>
</tr>
<tr>
<td>Inverse relationship between animation and sound effects and age; younger children (6-12) like them more (Nielsen, 2005)</td>
<td>Yes</td>
<td>We added both animation and sound effects</td>
</tr>
<tr>
<td>Positive reactions to icons and mascots</td>
<td>No</td>
<td>We have a number of icons but still do not have a mascot for the site</td>
</tr>
<tr>
<td>Name of website is important and ideally should be fun (Large et al., 2006)</td>
<td>Yes</td>
<td>We came up with the MSZ or “Middle School Zone”</td>
</tr>
</tbody>
</table>

While the current ratings from the high school and middle school design partners could still be higher, the new design process including age-appropriate youth design partners appeared to be successful. Table 3 below summarizes the focus groups results by age group illustrating the changes over time.

Table 3. Focus group and survey results by age group

<table>
<thead>
<tr>
<th>Age Group</th>
<th>Version Evaluated</th>
<th>M</th>
<th>SD</th>
<th>Likes</th>
<th>Dislikes</th>
</tr>
</thead>
<tbody>
<tr>
<td>MIDDLE SCHOOL</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Focus Group 1 (n=7)</td>
<td>v.5</td>
<td>6.7</td>
<td>.756</td>
<td>Colors and graphics</td>
<td>Color coordination; dense information</td>
</tr>
<tr>
<td>Focus Group 2 (n=21)</td>
<td>v.75</td>
<td>4.3</td>
<td>1.24</td>
<td>Information and personal testimonials</td>
<td>Dull color; lack of interactivity</td>
</tr>
<tr>
<td>Advisory Design Group Meeting 1 (n=3)</td>
<td>v.5</td>
<td>6.0</td>
<td>.707</td>
<td>Good colors, clear titles, kid friendly, good resources, good projects</td>
<td>Aesthetics, links, layout, needs interaction</td>
</tr>
<tr>
<td>Advisory Design Group Meeting 2 (n=2)</td>
<td>v.75</td>
<td>7.5</td>
<td>.691</td>
<td>Like “real stories”, bright colors, interesting, like options</td>
<td>Needs patterns in the background, still a bit dull, needs color backdrops</td>
</tr>
<tr>
<td>Advisory Design Group Meeting 3 (n=2)</td>
<td>v.1.0</td>
<td>8.3</td>
<td>.354</td>
<td>Liked blog, tests and polls; You did a good job with overall appeal of the site and the colors are great!</td>
<td>Colors and text style are a little too cute; I think you should add some more links to the site</td>
</tr>
</tbody>
</table>

HIGH SCHOOL

<table>
<thead>
<tr>
<th>Age Group</th>
<th>Version Evaluated</th>
<th>M</th>
<th>SD</th>
<th>Likes</th>
<th>Dislikes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Focus Group 1 (n=6)</td>
<td>v.5</td>
<td>5.8</td>
<td>1.72</td>
<td>The banner and pictures</td>
<td>Color is too bright and not well coordinated; need more graphics “Boring;” need more colors and interactivity</td>
</tr>
<tr>
<td>Focus Group 2 (n=12)</td>
<td>v.75</td>
<td>6.2</td>
<td>2.62</td>
<td>Ability to play music and access to information</td>
<td></td>
</tr>
</tbody>
</table>
Discussion

Although best practices for designing age-appropriate web spaces have been previously identified through the literature, our findings suggest it is difficult to change the adult-centric paradigms of typically adult designers and developers; these prioritize efficiency and clean designs that minimize extraneous information such as animation, audio, and other interactive features that distract from the information seeking process. When the study first began, the design called for identifying and leveraging best practices from the literature to design highly efficient and effective age-appropriate youth web spaces. Because satisfaction ratings of progressive iterations of both high school and middle schools sites actually decreased amongst representative users, it quickly became clear that a significant gap between what the adult designers deemed “age-appropriate” and what actually was youth appropriate had occurred.

Often the greatest lessons are learned through lack of success; after reflecting on the results of the first and the second versions and the changes that were made based on user feedback, it became clear that although some aspects of the design had improved others had not. For example, while the color coordination of the second iteration of the middle school site was refined based on user feedback, in doing so, some of the original bright colors preferred by this age group were muted. Another finding was that the design team relied too heavily on a combination of our adult-centric design experience and adult oriented web design guidelines and failed to accurately incorporate existing research on how middle school age and high school age information seeking preferences were different.

One of the central problems in developing websites that creates an environment which successfully supports and facilitates user information seeking, is that they are often designed by those who are not well informed of either user or organizational goals or information needs (Lin, 2007). The result is a site that serves as merely an information resource comprised of sources written by many different people with equally disparate goals and objectives. In this case, the designers, although well versed with organizational goals, certainly embodied this typically occurring problem in terms of user needs, especially given an adult-centric information seeking paradigm.

The major design flaw: Not including “representative” users

The major design flaw was failing to include middle school and high school aged users at the beginning of the design process. Referred to as user groups in traditional usability (Jordan, 1998), including members of the typical users of a site in the design process should protect against the very real threat of using the site designers’ current paradigms to create web spaces that may ultimately prove to be a highly inappropriate match between site and user goals. Most importantly, this disconnect can be prevented in the initial stages of design and development as opposed to during usability testing when a significant amount of time and resources have already been allocated. Representative users must be design partners as opposed to merely testers of an already potentially flawed design.

Identifying best practices from the literature provided the vocabulary to isolate these design flaws. Working directly with middle school and high school youth in the redesign process allowed the design team to better operationalize such subjective terms as “cool,” “interactive,” and “professional yet not boring” from a youth-centered perspective. The ability to design a web space using existing user paradigms can be referred to as concept actualization or the ability to authentically embrace and implement a concept in site design through the lens of the users who will be utilizing the site. Concept actualization took place through a set of steps, which represented an additional step to the DDE model—Engagement. By combining best practices identified by the literature, and our own experience, we
have developed a new design model—Engage, Design, Develop, and Evaluate (EDDE) for developing youth-appropriate web spaces as outlined in Table 4.

### Phase 1: ENGAGE...

<table>
<thead>
<tr>
<th>1. Design partners</th>
<th>Put together a small group of age-appropriate users as your design partners</th>
</tr>
</thead>
<tbody>
<tr>
<td>2. Age-appropriate user group</td>
<td>Keep group together so you can seek constant and consistent advice on design standards, specifications, and general perceptions and opinions</td>
</tr>
<tr>
<td>3. Web designers and developers</td>
<td>Ensure web designers and developers are meeting directly with your youth design partners. Seek concept actualization</td>
</tr>
</tbody>
</table>

### Phase 2: DESIGN...

<table>
<thead>
<tr>
<th>4. Site specifications (i.e., using Word processing software, Photoshop, etc.)</th>
<th>List main goals of site in priority order</th>
</tr>
</thead>
<tbody>
<tr>
<td>5. Information architecture (i.e., using Word processing software, Photoshop, etc.)</td>
<td>Create information architecture map detailing main channels and sub pages</td>
</tr>
<tr>
<td>6. User interface on paper (i.e., using Word processing software, Photoshop, etc.)</td>
<td>Establish general design elements of color, format, layout, etc.</td>
</tr>
<tr>
<td>7. Usability test (i.e., using Word processing software, Photoshop, etc.)</td>
<td>Show design to youth design partners; test information architecture through scenario and task completion</td>
</tr>
<tr>
<td>8. Refinement</td>
<td>Refine site based on user feedback and usability testing.</td>
</tr>
<tr>
<td>9. Usability test</td>
<td>Seek user feedback on refinements made (formal testing not necessary)</td>
</tr>
</tbody>
</table>

### Phase 3: DEVELOP...

<table>
<thead>
<tr>
<th>10. Alpha version of the site</th>
<th>Using HTML, XHTML, web design software, etc., develop web pages with images, animations, color, information, hyperlinks, selected functionality, etc.</th>
</tr>
</thead>
<tbody>
<tr>
<td>11. Usability test</td>
<td>Show initial version to design partners; test information architecture and all design and functional elements through scenario and task completion.</td>
</tr>
<tr>
<td>12. Beta version of the site</td>
<td>Incorporate results of testing into refined version</td>
</tr>
<tr>
<td>13. Usability test</td>
<td>Show refined version to design partners; test information architecture and all design and functional elements through scenario and task completion.</td>
</tr>
<tr>
<td>14. Usability test final beta version</td>
<td>Seek user feedback on refinements made (formal testing not necessary)</td>
</tr>
<tr>
<td>15. Version 1.0 and release to public</td>
<td>After making final refinements roll site live (note: certainly another iteration of design and usability testing can occur)</td>
</tr>
</tbody>
</table>

### Phase 4: EVALUATE...

| 16. By collecting user feedback informally | Informally collect user feedback by utilizing an online survey and/or user feedback/comment box that is available anytime |
| 17. Through formal usability testing | Conduct usability test by engaging age-appropriate users that are not design partners; test information architecture and all design and functional elements through scenario and task completion |
| 18. Results to refine site accordingly leading to start of second Engagement phase. | Utilizing results begins refinement and starts the design and development of a second version of your site. This begins the entire EDDE process again |

Table 4. The EDDE youth website design model

### Conclusion

### Limitations and implications

The study has three primary limitations. First, high school and middle school sample sizes are too low to generalize findings beyond this study. Second, bias with the advisory group ratings exist as each group provided three different
ratings on design iterations based directly on their input. Lastly, as the sites were reviewed as a focus group, social desirability may have been a confounding variable that contributed to the overall consistency of survey results.

This study contributes to the literature in three primary ways. First, it further validates differences between high school and middle school information seekers and provides concrete examples and discrete tables that can be used as checklists for web designers to understand the unique information needs of youth. Secondly, the study serves as an applied case study of the difficulty of implementing appropriate designs that effectively incorporate the unique information needs of disparate age-groups, especially as these differences may be contrary to existing design and development paradigms held by the designers that govern adult information seeking.

Finally, when utilizing the principles of information architecture, usability, and marketing, the unique information-seeking environment of the web represents one of the single most important factors that must be considered. In the case of this study, designers successfully aligned organizational goals with the major information goals of our website in the planning stages but failed to incorporate user preferences, mostly in graphic design and user control elements such as animation and interactivity, which are consistent with the different user expectations based on age-group and keeps information seekers engaged enough to remain on a particular website.

Opportunities for future study will focus on generalizing the study’s findings to a larger, more representative sample of high school and middle school users. In addition, the design team will need to create user groups centered specifically on middle school and high school-aged youth who can help through a multi-layered set of evolving roles as user, informant, test, and overall design partner (Druin et al., 1999). By recognizing major initial design flaws, which stemmed largely from not following a consistent, research supported design and development process, the study has reinforced how critical it is to follow a systematic and carefully followed design process that embraces pervasive usability and user input leading to concept actualization throughout the entire design and development lifecycle. The affective domain and its impact on youth information seeking needs to also be further examined. This research can serve as a roadmap for others to follow that will help facilitate more highly usable web spaces for youth.

References


Raise Your Hands or Hands-on? The Role of Computer-Supported Collaborative Learning in Stimulating Intercreativity in Education

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ABSTRACT
Young people are often referred to as digital natives, who are familiar with digital technologies such as computers, the Internet and mobile phones for communication, entertainment and accessing information. As a result scholars have called for an educational approach that bypasses the traditional unidirectional lecture teaching style, and applies a more hands-on, learner-centered method, which includes information and communications technologies (ICT) environments and applications. Building on the outcome of expert interviews, focus group conversations and public test cases in two research projects, i.e., “Bewaring en Ontsluiting van Multimediale data in Vlaanderen” (Archiving and Distribution of Multimedia in Flanders—BOM-VL) and “Multi-touch Multimedia Table” (MuTable), we want to reflect on the following questions by elaborating on the North Belgian (i.e., Flemish) context: How does the adoption of touch interfaces influence teaching and learning processes in classrooms and what are the implications for teaching models (traditional versus more interactive models)? Besides elaborating on the (attitudinal) bottlenecks and (pedagogical) opportunities of multi-touch displays in educational contexts, we discuss the implications for models of ownership of learning processes.

Keywords
Computer-supported collaborative learning, Multi-touch technology, Intercreativity, Educational policy, Learning models

Introduction
Young people, at least within Western societies, have been widely referred to as digital natives, for whom digital technologies such as computers, the Internet and mobile phones are natural, self-evident and ever-present (Bauwens et al., 2009; Livingstone, 2002a; 2002b; Livingstone & Bober, 2005). Many have pointed to the increasing diffusion and availability of Information and Communication Technologies (ICT) in the lives of many teenagers, whereas others have emphasized their appropriation practices and signification processes (Bauwens et al., 2009; Livingstone et al., 2010; Mediappro, 2006; Ofcom, 2006). The ways in which young people engage with media and ICT have been described and analyzed in various ways. The result is a plethora of concepts, often referring to a “collaborative” dimension of interacting with both peers and content: “remixing,” “self-publication,” “role-playing,” “collective intelligence,” to name only a few (Jenkins, 2006; Parker, 2010). As a consequence, a growing body of scholars has, not entirely uncontested, called for substantial educational reforms responding to the ICT skills and practices of these generations (Bennett, Maton & Kervin, 2008). However, one finds that ICT (e.g., personal computers, cameras) that have been put in place in classrooms still tend to promote a rather traditional, ex-cathedra, teaching approach. This paper explores the opportunities of multi-touch technology as a more interactive and collaborative technology that applies a hands-on, learner-centered and bottom-up learning approach. By drawing on own data, gathered via two multi-method qualitative research designs conducted in Flanders (the Northern region of Belgium), we aim to address the following question: How does the adoption of touch interfaces, influences teaching and learning processes in classrooms and what are the implications for teaching models (traditional versus more interactive models)?

Context and literature review

The discontinuity between young people’s ICT practices and the increasingly growing advocacy for educational reforms on the one hand and the available technologies implemented in classrooms on the other hand is at the heart
of this article. By drawing on a multi-disciplinary body of literature, i.e., joining the fields of media and communication studies, sociology and learning sciences, we aim to lay a thorough foundation to discuss own research findings gathered in Flanders on the opportunities and pitfalls of interactive, collaborative and learner-centered tools in education. After sketching the broad, conceptual framework of this article, based on theories of computer-supported collaborative learning (CSCL), we will concentrate on the Flemish context and elaborate on a number of key factors influencing and characterizing the educational use of ICT in Flanders, i.e., the widespread diffusion and appropriation of ICT amongst teenagers in Flanders and the educational policy and floor situation with regards to ICT penetration.

Creativity, collaboration and intercreativity in computer-supported collaborative learning

Cultural studies scholars and critical media educationalists, and educational (policy) professionals, cultural institutions and industries (e.g., public services broadcasters, museums) share the idea that a creative use of ICT and digital technologies is vital to the development of young people, both as cultural citizens and as cultural consumers (Burgess, 2006; Goodman, MacCallum-Stewart & Munsell, 2009). Creativity enables them to use ICT “to their own advantage, and to the advantage of a more informed and more equally empowered digital, and real world community” (Goodman, MacCallum-Stewart & Munsell, 2009). Although this notion of an enlarged and empowering creativity for young people dates back to the pre-Internet era (Willis, 1990) it is clear that its appeal has grown significantly with the rise of an Internet that is built on participation, collaboration and user-generated content, i.e., the so-called Web 2.0. Together with the creative industries and new forms of economy and entrepreneurship, the theories and debates about new forms of learning seem to have converged into a strong belief in the creative potential of ICT and of young users (Burgess, 2006; Hermes & Janssen, 2006; Notley & Tacchi, 2004).

In addition, youth studies and media educational projects have pointed out that digital media creativity among young people is a social process that inevitably entails social negotiations between peers, explorations of the relationship between the self and the others and performances of social identities like gender, ethnicity and class (Buckingham, 2008; de Leeuw & Rydin, 2007). Today the social dimensions of digital creativity have regained new interest because of the concurrence of user-generated content, social software and new technological devices (Burgess, 2007). From the various studies and research projects on young people and their creative ICT use, it transpires that digital creativity today is very often conceived in terms of intercreativity. This concept, introduced by Berners-Lee (1999), has been used not only to refer to the interconnection of the Internet and creativity, but also to articulate the close link between interactivity and creativity, since it emphasizes the possibilities of creating together and being creative together. Burgess (2007) argues that the concept epitomizes the conceptual shift from interactivity - the buzzword in the early 1990s - to a more powerful sense of user engagement with media texts, individualized and personalized media use and greater user choice. In the work of Meikle (2002), the notion of intercreativity suggests a more emancipated, autonomous and free use of ICT. It not only relates to the potential to interact, but also to the opportunity to create new content in a collaborative and communicative way.

As young people apply ICT to empower their creative skills and social processes, creativity, collaboration and intercreativity have become effective means to develop new competences. This is also characterized within computer-supported collaborative learning (CSCL), a branch of the learning sciences concerned with the study of how people can learn together with the help of computers. CSCL arose in the 1990s in reaction to software that forced students to learn as isolated individuals. Instead, it proposes the development of new software and applications that bring learners together and offer creative activities of intellectual exploration and social interaction. CSCL stresses collaboration among learners, so that they are not simply reacting in isolation to materials. The learning takes place largely through interactions. People learn by expressing their questions, pursuing lines of inquiry together, teaching each other and seeing how others are learning (Phielix, Prins & Kirschner, 2010; Stahl, Koschmann & Suthers, 2006).

Research has generated contradictory results concerning the cognitive and social benefits of CSCL environments as compared to contiguous face-to-face groups (for an overview see Phielix, Prins & Kirschner, 2010). While a number of studies on the cognitive aspects of collaboration find that students working in CSCL environments report higher levels of learning, make higher quality decisions, deliver more complete reports, participate more equally, and engage in more complex, broader, and challenging discussions than students working face-to-face, other research finds that students working in CSCL environments sometimes perceive their discussions as more confusing, less
Research into ICT use indicates an increasingly diversified pattern. The computer is used mainly to listen to music, example, 97% of Flemish teenagers own a mobile phone and 85% has an mp3-player ("Apestaartjaren," 2010). In addition, teenagers' households a game console (other than the computer) can be found (Bauwens et al., 2009). In addition, teenagers' television (99%) and computers (97%) with Internet connection (94%) is nearly universal. In almost 90% of the research reveals that ICT is widely available for many teens in Flanders. In households with children, access to computers only for schoolwork (Bauwens et al., 2009). Furthermore, studies show that many young people are engaged in diverse online activities where they exchange, receive, re-interpret and rework various symbolic meanings. The merge of user-generated content and social software (Burgess, 2007) affects the Internet practices of many young people (Burgess, 2006; Lenhart et al., 2007; Livingstone, 2002a, 2002b, 2004, 2008). Today, social software, community and communication are considered to be crucial constituents of creativity (Bauwens & Vleugels, 2010; Loveless, 2006). Many argue that the re-use of existing material (like in manipulating, remixing, remediating and recombining) gives way to aesthetic and learning experiences and “collage creativity” (Drotner, 2008), “bricolage” and “intertextuality,” “dialogic communication” (Buckingham, 2003), or “produsage” (Bruns, 2005, 2007, 2008) are constituent aspects of young people’s creative expression (Burgess, 2006; Stern, 2008).

Diffusion and appropriation of ICT amongst Flemish teenagers

Plenty of ingredients are in place in order to facilitate computer-supported collaborative learning in Flanders. Recent research reveals that ICT is widely available for many teens in Flanders. In households with children, access to television (99%) and computers (97%) with Internet connection (94%) is nearly universal. In almost 90% of the households a game console (other than the computer) can be found (Bauwens et al., 2009). In addition, teenagers' bedrooms have become media-rich environments (television: 46%, computer: 43%) where they can go online (62%) ("Apestaartjaren,” 2010). On a school day, the average amount of the reported time spent online is 2 hours, on Wednesdays (when Flemish teens have a free afternoon) 2.5 hours and on free days and weekend days this number increases to more than 3 hours (Bauwens et al., 2009). In addition, young people are increasingly mobile. For example, 97% of Flemish teenagers own a mobile phone and 85% has an mp3-player ("Apestaartjaren,” 2010).

Although interactive tabletop displays and interactive whiteboards have been around for more than 20 years, their popularity in public spaces increased during the last decade. Early systems did not have (integrated) displays and were based on multi-touch tablets sensing touch input (Kurtenbach, Fitzmaurice et al., 1997; Lee, Buxton et al., 1985). Since the advent of large displays equipped with multi-touch technology more natural ways of interaction with computers have unfolded. Direct manipulation of content becomes the main interaction technique and is often more intuitive than traditional interaction techniques. In a collaborative workspace it is important to develop individual tasks as well as on mutual ones. Still, most of the multi-touch hardware technologies nowadays identify many touch-points, but not the users associated with them. In the MuTable project (see below), we dealt with this issue by assigning each user with a delimited space on the touch-screen where he or she is allowed to work on his or her individual task. However “ownership” of workspaces is not strictly individualized: Users can work alone, or they can share a workspace among several users (Schneider et al., 2010). Numerous experiments have already considered this issue of workspaces and ownership of digital artifacts (Dietz & Leigh, 2001; Scott & Carpendale, 2004; Scott, Grant et al., 2004; Tuddenham & Robinson, 2009). Touch-sensitive devices thus might be able to act as a platform for (inter)creative collaboration and learning.

Research into ICT use indicates an increasingly diversified pattern. The computer is used mainly to listen to music, for chatting with friends and meeting up on social networking websites, to watch videos, for searching information, e-mail and homework. For their homework, teenagers make frequent use of the Internet for gathering information, although sources other than Google and Wikipedia are rarely consulted and discussing homework by Instant Messaging or telephone is part of school-going teenagers' daily life. Moreover, outside the home environment, a friend’s house (77.0%) and school (62.6%) are rather common places to access the Internet (Bauwens et al., 2009). A closer look at young people's usage of computers at school reveals that it rises according to grade: from 54.9% in the first grade of secondary school to 72.5% in the third grade. Computer use at school is mainly limited to lessons (44.3%). Only 10.6% of the pupils use computers outside classes and the majority (55.5%) is allowed to use computers only for schoolwork (Bauwens et al., 2009). Furthermore, studies show that many young people are engaged in diverse online activities where they exchange, receive, re-interpret and rework various symbolic meanings. The merge of user-generated content and social software (Burgess, 2007) affects the Internet practices of many young people (Burgess, 2006; Lenhart et al., 2007; Livingstone, 2002a, 2002b, 2004, 2008). Today, social software, community and communication are considered to be crucial constituents of creativity (Bauwens & Vleugels, 2010; Loveless, 2006). Many argue that the re-use of existing material (like in manipulating, remixing, remediating and recombining) gives way to aesthetic and learning experiences and “collage creativity” (Drotner, 2008), “bricolage” and “intertextuality,” “dialogic communication” (Buckingham, 2003), or “produsage” (Bruns, 2005, 2007, 2008) are constituent aspects of young people’s creative expression (Burgess, 2006; Stern, 2008).
A receptive educational policy ground

The educational meaning of digital practices and creativity has increasingly developed into the focal point of academic and policy-related debates. Recent research identified 1,200 curricula documents in 27 European countries and analyzed them using the search terms “creativity” and “innovation,” their stems and five synonyms. This wordlist was used for content analysis, with the documents in their national language, and provided the number of hits (frequency count), concordances (list of occurrences within their context), and co-locators (certain words that frequently occurred next to or near the search terms) (Heilmann & Korte, 2010). The research revealed that when ICT are mentioned, they are rarely associated with creativity. Sometimes ICT are implicitly present, through the use of expressions like “computer,” “new media” and “media competence,” or referred to as tools for teaching and learning processes. Compared to other European countries and regions, Flanders is part of the group that is ranked medium in terms of the relative occurrence of creativity and innovation in curriculum documents, i.e., general documents and subject-based curricula (Heilmann & Korte, 2010).

Overall, two major approaches to creativity appear in the curricula of European countries. When creativity is defined as a creative task or activity, then it is usually linked to specific subjects such as Arts, Music, Languages and Technologies. The focus is on doing things creatively. The other approach conceives creativity more broadly and considers it as a generic skill, like “creative thinking” or “creative problem solving,” which should be encouraged and developed throughout all subjects. In this rather transversal approach, the word creativity is often linked to capacity building, empowerment, self-expression and (personal) development of pupils and students (Heilmann & Korte, 2010).

In Flanders, a notable policy measure is the introduction of a novel set of cross-curricular attainment targets in secondary education as of 1 September 2010. These are minimum requirements that do not affect a specific subject, but are pursued by means of and throughout different subjects and educational projects. One of these novelties is the cross-curricular attainment target “Mediawijsheid” (“Media Wisdom,” own translation), which is supported by both the Flemish policy plan Media (2009-2014) and the Flemish policy plan Education (2009-2014). By focusing on “the whole of knowledge, skills and mentality which enables citizens to consciously, critically and actively engage in a complex, changing and fundamentally mediatised world” (policy plan Media, i.e., Lieten, 2009, p. 22, own translation) and “arming pupils against misleading advertising and learning them to rationally deal with credit facilities” (policy plan Education, i.e., Smet, 2009, p. 16, own translation), it joins in with its European pendant “media literacy.” The latter emphasizes the development of knowledge and skills that are required to access, critically evaluate and create media content (European Commission, 2009, p. 3). Nonetheless, several related concepts are in place (e.g., digital literacy, media competence), causing challenging conceptual debates (Livingstone, 2004). The Flemish attainment target “Mediawijsheid” links up to the cross-curricular attainment target “ICT” which has been in place since 2007. Whereas the attainment target “ICT” conceives ICT roughly as means to an end (e.g., communication), the novel target emphasizes them as objects of a process in which pupils acquire certain generic attitude and skills when dealing with ICT and media content. Nonetheless, both their conception and structural embedment can be considered as indications of the growing willingness and awareness of the need to incorporate digital media and content in a meaningful educational manner.

Gradual ICT penetration

Large-scale and long-term research into the integration and actual use of ICT classrooms in Flanders is still developing. The report “Monitoring ICT in het Vlaamse Onderwijs” (“Monitoring ICT in Flemish Education,” Evers et al., 2010), issued by the Ministry of the Flemish Community, Department of Education, gives an account of the integration of ICT in Flemish primary and secondary compulsory education, i.e., for the period 01/01/2007 until 31/12/2008. With approximately 1 computer for every 6 pupils in mainstream elementary education (n = 231) and roughly 1 computer for every 3 pupils in mainstream secondary education (n = 97), Flemish schools attain considerably decent scores in light of the European average of 1 computer per 10 pupils in primary education and 1 computer per 8 pupils in secondary education (Balanskat, Blamire & Kefala, 2006; Korte & Hüsing, 2007). Moreover, the pc/pupil ratio in mainstream secondary education mostly corresponds to the pcInternet/pupil ratio. This implies that when pupils work on computers in mainstream secondary education they generally also have an Internet connection at their disposal (predominantly broadband). Thus Flemish schools join in with the European average rate of Internet penetration (i.e., 96%; Korte & Hüsing, 2007, p. 30). The monitoring report also examined
the location of computers: In elementary education computers are located in the classroom; in secondary education, they are mostly sited in distinct computer classrooms.

With a shared focus on personal computers as computer hardware in education, these and similar large-scale international reports are bypassing the opportunities of other ICT which have been introduced in educational settings, notably digital whiteboards. However, for the first time on this scale, Evers et al. (2010) have recorded the distribution of digital whiteboards in Flemish education. Throughout the three educational networks, i.e., (1) the public school system GO! Gemeenschapsonderwijs, (2) the publicly funded, publicly run educational network Officiele Gesubsidieerd Onderwijs and (3) the publicly funded, privately run educational network Vrij Gesubsidieerd Onderwijs, respectively 10% (n = 56), 5.13% (n = 78) and 6.95% (n = 187) of mainstream primary schools and 62.16% (n = 37), 28.57% (n = 14) and 15.48% (n = 84) of mainstream secondary schools have digital whiteboards. In addition, the report indicates that many schools do not have digital cameras at their disposal, in particular in primary education: 8.41% of mainstream primary schools (n = 321) and approximately 30% of mainstream secondary schools (n = 135) have digital cameras.

Own research

The recent introduction of ICT-related attainment targets and the growing availability of ICT hardware and software in schools can be considered as indications of an increasing policy awareness of the need to address the digital activities and practices of young people to a certain extent. However, the technologies that have been implemented, exemplified by the digital whiteboard, still promote a rather traditional, ex cathedra and top-down teaching approach. Through own research findings, this section explores the opportunities of other, more interactive and collaborative, technologies that apply a hands-on, learner-centered and bottom-up learning approach.

An experimental case study with multi-touch technology

The BOM-VL project (“Bewaring en Ontsluiting van Multimediale data in VLaanderen,” the Dutch acronym for Archiving and Distribution of Multimedia in Flanders, January 2008 – June 2009) aimed to find sustainable solutions for obstacles to processes of archiving, preserving and distributing digital audiovisual content originating from the cultural sector as well as audiovisual broadcasters in Flanders. Problems addressed within the project are manifold: They include among others user (group) requirements, legal aspects of digital content distribution and technological architectures for archiving and distribution, each devised into separate trajectories. Prior to this project, these issues had never been addressed on a large scale and in such a comprehensive multi-disciplinary fashion in Flanders.

The MuTable project (the Multi-touch Multimedia Table) that ran from January 2008 until December 2009 explored the potential use of multi-touch related applications in, among others schools and aimed at creating a new software architecture for multi-touch multimedia interaction in public contexts. Throughout this article, the term “MuTable” will be used to refer to the prototype of the interface for multi-touch multimedia interaction that has been developed within the project. It is a touch-sensitive device that can act as a platform for collaboration, communication and presentation between teachers and learners and between learners themselves.

Methods

By means of in-depth respondent interviews within three stipulated target groups in the BOM-VL project, i.e., the educational sector (three), the audiovisual creative industry (three) and cultural institutions (three), the viability of different distribution models within the different sub-sectors were mapped and assessed. The respondents were selected based on their domain-specific expertise, the position they hold in the field and their ability to transcend sectoral visions and issues. The interviews, conducted in the period February-March 2009, were built on semi-structured interview schedules in order to maximize the comparability and increase the reliability and credibility of data whereas a number of questions and sub-questions were presented less rigidly as discussion topics. Furthermore, they were fully transcribed, coded and analyzed by means of a pre-structured analytic schedule. In this article we particularly draw on the interviews with the educational professionals and discuss their views on the distribution of digital audiovisual content in Flemish education.
In the MuTable project, an experimental setting was created for 22 second-year pupils in secondary education (13 year olds) in which the type of interface, i.e., multi-touch multimedia interface versus regular PC interface, was the “experimental manipulation” (Loosveldt, 2001). Besides participant observation during the experiment, two focus group conversations were organized with 18 first-year pupils (12 year olds) and their teachers (two) and one focus group with heads of departments (three) in order to assess the potential value of multi-touch technology within the educational context; what content they are willing to provide; what links they are willing to provide between their content and content of other public spaces; and what links they are willing to provide between their public space and the private sphere of users.

Results

Intercreating Leonardo Da Vinci

The design and development of the multi-touch applications were based on a scenario of a school assignment in which the teacher divides the class in different groups and instruct each group to research a specific topic and later present the findings in front of the class. In our case study the pupils were instructed to make a presentation about the life and work of Leonardo Da Vinci. Half of the pupils made the presentation by means of the MuTable interface, whereas the other half, two by two, made a web quest and a presentation on regular computers using standard web search. They were all able to search for additional content (text documents, pictures, movies) to integrate in their presentations.

Because the pupils were familiar with each other, a safe learning environment was created—a condition for collaborative learning—in which pupils dare to share their thoughts and ideas about what the presentation should contain and look like. In combination with the free and autonomous use of technology, intercreativity was stimulated which resulted in the emergence of many different presentations. Intercreativity was not only demonstrated while developing the presentation, but also when newcomers were introduced to the multi-touch interface. At the beginning, three pupils were chosen by the teacher to perform the task. They were introduced to the applications and possible gesture actions by the researchers. During the assignment three other pupils were invited to continue the task. They were easily introduced to the possibilities by peer-to-peer learning by the first group. In general, it was striking how easily, quickly and effectively second year pupils were dealing with the technology.

Although collaboration, creativity and interactivity occurred at the multi-touch setting as well as at the PC setting, the latter limited the possibilities for intercreativity. Pupils working on the computer were limited because of the single point interface (the mouse) and the fact that only one pupil was able to operate the interface at a time. As a result, pupils discussed the web quest, however, only one pupil could perform the information search, and create and embed the information in the presentation. Moreover, in some of these groups we witnessed free-riding behavior because of the lower interdependence between pupils. Simultaneously, the multi-touch interface stimulated individual accountability as all pupils could collaborate and create in a hands-on manner. As a result, the constellation enhances a sense of shared responsibility and engagement.

Teachers’ reservation

Focus group findings indicate that the MuTable is considered a preferable instrument for pupils working together on group tasks in a classroom, rather than an alternative for interactive whiteboards. In the same breath, however, they stressed that the contexts in which this bottom-up approach of collaborating on digital materials are limited, either due to infrastructural or attitudinal issues teachers are deemed to consider this new pedagogy as a threat to their status as “the expert.” Moreover, interviews in both BOM-VL and MuTable have indicated that working with digital content and materials assumes a certain commitment and attitude of teachers, both of which appear to be challenging. MuTable participants have pointed to the need for specialization when it comes to dealing with a technology such as the MuTable; if not, insufficient use prevails, such as digital whiteboards that are used as mere beamer-like presentation tools.

With that, however, few teachers are deemed “ICT-minded.” Hence this would presuppose an additional commitment as they are faced with the challenge of refashioning teaching methods and adapting teaching materials.
Accordingly, informants in the BOM-VL project pointed to the importance of sectoral consultation and specifically the involvement of teachers when it comes to the contextualization and findability of educational content. However, when relating topics such as user-generated content and metadata creation (e.g., to attune content and metadata creation to attainment targets) were brought to the fore, informants underlined the need for a change in attitude. Not only did they reckon teachers that work with digital materials and content rather scarce, they also expressed a need to incorporate such materials in teaching practices in a meaningful manner, i.e., by exceeding mere illustrative and descriptive use and focusing on the intrinsic typology and value of images (Mostmans et al., 2009, p. 10). Notably, this need is addressed in the aforementioned cross-curricular attainment target “Mediawijsheid” and has also been referred to in MuTable interviews: Educational professionals described the MuTable device as an adequate interactive tool in which subject-specific assignments can be set out in order to obtain other cross-curricular attainment targets.

Discussion

Advocating an interactive and more learner-centered teaching approach

Recent European research has shown that creativity is frequently espoused and promoted in curricula and policy documents. Nevertheless, a gap is perceived between the rhetoric in such documents and the realities in schools (Banaji et al., 2010; Cachia & Ferrari, 2010; Heilmann & Korte, 2010). In this article, we reflected on how the adoption of ICT influences teaching and learning processes in classrooms and what the implications are for teaching models. Illustrated by the recent introduction of two ICT-related cross-curricular attainment targets in Flanders, the digitization of educational settings has been a growing point of interest within policy spheres. With that, efforts to provide adequate infrastructure have been noticed. Computers have become widespread in primary and secondary education in Flanders, and other ICT are gradually making their way.

The MuTable project has shown that the interface as a portal integrates the retrieval, analysis and presentation of information in a creative and interactive manner. Thereby it responds to young people’s common practices to interact with digital materials and with each other. Moreover, it opens up opportunities for children to take ownership of their own educations and to be a part of the process. This can mean more engaged learners, proud about their work and what they are learning about. Further, the case study has indicated that certain ICT allow pupils to perform a more complex and multi-disciplinary assignment, which contributed not only to their knowledge about the historical figure of Leonardo Da Vinci, but also to their creativity and technical skills. Whereas the traditional PC setup with mouse interface limited the collaboration of one pupil actually handling the computer, while the other pupil provided verbal input, the multi-touch setup enhanced real-time hands-on collaboration. We can therefore draw the hypothesis that multi-touch technology can offer new opportunities for both formal and informal learning, not only because of the multi-user aspects relating to interaction, but also the opportunity of creation in a collaborative and communicative way. As such, multi-touch technology fits in with Meikle's notion of intercreativity (2002). In this process of hands-on collaboration, learners are not simply reacting in isolation to created and shared materials; they learn by expressing their questions, pursuing lines of inquiry together, teaching each other and seeing how others are learning. Therefore, a role of technology can be to support collaboration by providing media of communication and scaffolding for productive interaction between learners.

Moreover, there is a discrepancy between how teachers perceive creativity, interaction and collaboration on the one hand, and the way they would foster creativity and multi-touch technology during their teaching on the other hand. While during the focus group conversations - an abstract reflection about the possible added value—multi-touch technology was described as an ideal instrument for pupils working together on group tasks in the classroom, the teachers who attended the experiment showed examples of digital resources they already use and which they would like to integrate when using a multi-touch interface. The examples showed that multi-touch technology would be used primary as a presentation tool and as such it would not be more than a fashionable gadget. Therefore, if a hands-on approach is embedded within formal education, it needs to be made more widespread and systematic, and given sustained policy support, for instance at the level of teacher training.

It has to be noted that the case study was conducted in a highly ICT-equipped school, where teachers showed an open and progressive attitude towards ICT in classrooms. By and large, however, the general teachers’ attitude to adopting and integrating them into their teaching is lagging and the traditional unidirectional pattern of teaching still
appears to remain dominant: Teachers teach and pupils listen and record. The input of learners is usually restricted to raising hands when a teacher poses a question and to formulate an answer when they are chosen. Reflections on the adoption and integration of ICT in general and touch interfaces in particular in teaching and learning processes in classrooms are therefore all but straightforward. Teachers not only need to acquire certain technical (how to operate ICT) and pedagogical (how to integrate them into teaching practices) skills; a certain mindset is requisite. Moreover, given the cross-curricular nature of some of these attainment targets, a wide range of subject teachers can be faced with the need to (1) specialize and take extra training courses, (2) resourcefully renovate teaching methods and (3) adapt teaching materials. As such, questions as to whether, to which extent and in what manner ICT are readily usable in classroom environments become all the more relevant and need to be addressed in future research in Flanders.

References


Why do Individuals Use e-Portfolios?

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ABSTRACT
As the use of Information Technology (IT) applications has become more widespread, focus has turned toward applying IT to the learning domain, with policy initiatives aimed at integrating IT with teaching. E-Portfolios have assumed growing importance in higher education as institutions seek new teaching–learning–assessment tools to increase learner autonomy in virtual learning environments. Based on the Technology Acceptance Model (TAM) and Information System Success Model (ISSM), this research investigates and analyzes the attitudes, degree of satisfaction and acceptance of e-Portfolio system users. The results indicate that, among prospective users, attitude appears to have the strongest and most significant direct effect on usage intentions, while satisfaction serves as a preliminary condition to mediate the effect of the users’ attitude on intention to use. In addition, the utility users perceive in the e-portfolio system influences their attitude and intention more than it does their perceived ease of use. Moreover, service quality utility has a greater influence on user satisfaction and intention than does system quality and information quality. This model provides a systematic understanding of prospective users’ perceptions of the e-Portfolio system, and such an understanding could help in the development and promotion of e-Portfolio systems in educational contexts.

Keywords
Electronic Portfolio (e-Portfolio), Technology Acceptance Model (TAM), Information System Success Model (ISSM), Architectures for educational technology system

Introduction
A global effort has emerged to apply Information Technology (IT) to the learning domain, with principal educational policies focusing on integrating IT with teaching. Electronic portfolios (e-Portfolios) are one of a new range of new educational instruments with relevance to these efforts. Recently, many universities have joined e-Portfolio systems, which are seen as an innovative technique in instruction and evaluation (Lopez-Fernandez & Rodriguez-Illera, 2009; Chang et al., 2011). Love et al. (2004) cited e-Portfolios as having had “the most significant effect on education since the introduction of formal schooling.” However, implementing a school-wide e-Portfolio system for all students is not only expensive but also may run into problems from poor adoption rates on the part of students (Tzeng, 2011).

Several studies have been conducted on key factors in technology acceptance and the success of information system implementation. Davis (1986) proposed the Technology Acceptance Model (TAM), which has emerged as an important IT management theory. According to the TAM, whether or not users will accept an innovation such as a new computer system is determined primarily by two types of perceptions: whether using the system will enhance the users’ job performance (perceived usefulness), and whether the system will be easy to use (perceived ease of use). The TAM theorizes that these two perceptions exert substantial influence on the attitudes and behavioral intentions people have towards a system (Davis et al., 1989).

In the information system (IS) field, DeLone and McLean (1992) developed an IS success model (ISSM) containing six constructs: system quality, information quality, use, user satisfaction, individual impact, and organization impact. More recently, they revisited their ISSM by including service quality as an independent variable and net benefits as a combination of individual impact and organizational impact (DeLone & McLean, 2003). Finally, the empirical results showed that system quality, information quality, and service quality affect user satisfaction and intention to use.
Whether or not traditional IS success models can be extended to assessing the success of e-Portfolio systems is rarely addressed. The main objectives of this research is to explore the relationships among perceived ease of use, perceived usefulness, system quality, information quality and service quality, along with the moderating relationship of user personality between attitude and user satisfaction. This research also integrated TAM and ISSM as a foundation for exploring learner e-Portfolio use intention to establish a causal relational model for determining the likelihood of the successful integration of e-Portfolios in educational contexts. Finally, the findings of this empirical research will be useful to researchers in terms of developing and testing theories related to TAM and ISSM, and to practitioners in terms of understanding the strategies that underlie learner adoption of e-Portfolios.

**Literature review**

**Electronic portfolio (e-Portfolio)**

The e-Portfolio not only covers perceptions, affections, skills and relevant process but it ability to run in IT systems helps teachers integrate teaching and assessment to evaluate student ability and learning results from different angles. Attwell (2007) acknowledges that “there is not one generic approach but multiple approaches that are based on different pedagogic understandings of the purposes and processes of using e-portfolios for teaching and learning” (Attwell, 2007, p. 41). Taiwan’s Ministry of Education has been promoting Excellence Programs among colleges and vocational high schools which have started e-Portfolio systems, and other schools are encouraged to build systems to help students establish e-Portfolios. This research aimed at using an evaluation model to determine intention and satisfaction with e-Portfolios, and thus help schools to develop and promote e-Portfolios internally among teachers and students.

**Technology Acceptance Model**

Davis et al. (1989) proposed the TAM based on Fishbein and Ajzen’s (1975) Theory of Reasoned Action (TRA) and derived the Theory of Planned Behavior (TPB) in coordination with information system application scenarios to explain and predict user adoption of IT as the determining factor. TAM explores the relationship between the user’s sense and sensibility for technology applications to establish an acceptance model of IT users in the hopes of deriving a model of behavior intention from users’ acceptance of new technologies. User willingness to use a new technology explains or predicts the acceptance level of the new technology, and two key factors affect a user’s acceptance of a given type of information technology: perceived ease of use and perceived usefulness. That is, external variables that affect the acceptance of information technology are subject to perceived ease of use and perceived usefulness. Actual use is under determined by attitudes and intention to use. In other words, perceived ease of use and perceived usefulness are independent variables; attitudes toward using, intention to use and actual system use are dependent variables, as shown in Figure 1.

![Figure 1. Technology Acceptance Model (Adapted from Davis et al., 1989, p. 985)](image)

**Informational System Success Model (ISSM)**

DeLone and McLean (1992) integrated empirical studies with academic research conducted from over eight years, providing more general viewpoints on information systems and inferring the six dimensions of successful
information systems (system quality, information quality, use, user satisfaction, individual impact, and organization impact). In this model, system quality and information quality affect use of and satisfaction with the information system, which then affect individual behavior and, thus, the performance of organizations.

Over the years of development, some scholars have offered different viewpoints and suggestions on this model. Pitt et al. (1995) claimed service quality also affected an organization’s satisfaction with information systems. DeLone and McLean (2003) thus extended their original ISSM model (DeLone and McLean, 1992) to include intension to use in the original definition of “use.” Individual impact and organization impact were combined as “net benefits,” as shown in Figure 2. This research targets e-Portfolio system users, defining learning satisfaction as the positive or negative feelings or attitudes users display on the presentation of their e-Portfolio, process and results, to assess their intension to use the e-Portfolio. Satisfaction is a major factor affecting intension to use such a system.

**Conceptual model and hypotheses**

From the preceding discussions, the TAM focuses on the level of acceptance users have for a given information technology, the information technology in this case being defined as e-Portfolio. The two most important factors for prediction of attitudes and behavior intension are perceived usefulness and perceived ease of use, which are included in this research as variables to determine whether user acceptance of the system is connected to perceived usefulness and perceived ease of use. In addition, this research investigates how system quality, information quality and service quality directly affect user satisfaction based on ISSM. The research structure is illustrated in Figure 3, and we propose the following hypotheses:

**User motivation**

The motivational perspective has also been widely used to gain insight into individual behavior. Pintrich et al. (1989) developed the Motivated Strategies for Learning Questionnaire (MSLQ) scales and tapped into three areas, including

![Figure 2. Updated D&M IS Success Model (Adapted from DeLone & McLean, 2003, p. 24)](image-url)

![Figure 3. Research Model](image-url)
values (intrinsic and extrinsic goal orientation), (2) expectancies (self-efficacy); and (3) affect (test anxiety). In advance, Davis et al. (1992) found that intrinsic motivation and extrinsic motivation were key drivers of behavioral intention to use computers. Recent research has shown that the intrinsic motivation factor has a positive effect on the intention to use information technology (Liaw & Huang, 2003), and the extrinsic motivation factor was also found to have a positive effect on the intention to use computers (Bhattacherjee, 2000). Therefore, this research tested the following hypotheses:

H1-a: User motivation will have a positive effect on the perceived ease of use of e-Portfolios.
H2-a: User motivation will have a positive effect on the perceived usefulness of e-Portfolios.
H3-a: User motivation will have a positive effect on the perceived system quality of e-Portfolios.
H4-a: User motivation will have a positive effect on the perceived information quality of e-Portfolios.
H5-a: User motivation will have a positive effect on the perceived service quality of e-Portfolios.

**Computer self-efficacy**

Computer self-efficacy is defined as the judgment of one’s own ability to use a computer. Murphy et al. (1989) originally developed the Computer Self-efficacy Scale (CSES) and found that student perceptions of their own ability to use computers efficiently would notably improve their training and learning performance. The proposed relationship between computer self-efficacy and perceived ease of use is based on theoretical arguments from Davis et al. (1989) and Compeau et al. (1999). Empirical evidence also exists for a causal link between computer self-efficacy and perceived ease of use (Igbaria et al., 1995; Venkatesh & Davis, 1996) and perceived usefulness (Levy & Green, 2009). However, computer experience might be positively related to the concerns regarding the system quality, information quality, service quality of an e-Portfolio system. Therefore, this research tested the following hypotheses:

H1-b: Computer self-efficacy will have a positive effect on the perceived ease of use of e-Portfolios.
H2-b: Computer self-efficacy will have a positive effect on the perceived usefulness of e-Portfolios.
H3-b: Computer self-efficacy will have a positive effect on the perceived system quality of e-Portfolios.
H4-b: Computer self-efficacy will have a positive effect on the perceived information quality of e-Portfolios.
H5-b: Computer self-efficacy will have a positive effect on the perceived service quality of e-Portfolios.

**Perceived ease of use**

Perceived ease of use was found to directly and indirectly influence intention to use via perceived usefulness (Davis et al., 1989; Liaw & Huang, 2003). The present research defines perceived ease of use following Davis et al. (1989): “the degree to which a person believes that using a particular system would be free from effort.” This research follows this definition and also believes that e-Portfolio systems need to be both easy to learn and easy to use in order to prevent the “underused” useful system problem. IT that is easy to use will be less threatening to the individual. Thus, this research develops the following hypotheses:

H6: Perceived ease of use will have a positive effect on the user’s attitude toward using the e-Portfolio.

H11: Perceived ease of use will have a positive effect on the perceived usefulness of the e-Portfolio.

**Perceived usefulness**

Extensive research in the IS community provides evidence of the significant effect of perceived usefulness on user attitudes and usage intention (Davis et al., 1989; Shin, 2007). The present research defines perceived usefulness following Davis et al. (1989): “the degree to which a person believes that using a particular system would enhance his or her job performance.” Also, the ultimate reason that people exploit e-Portfolio systems is that they find the systems useful to their learning activities. Therefore, this research tests the following hypothesis:

H7: Perceived usefulness will have a positive effect on the user’s attitudes toward using the e-Portfolio.

**User attitude**

The user’s attitude towards using a technology-based system or service was determined by his/her beliefs regarding perceived usefulness and perceived ease of use (Davis et al., 1989; Karahanna & Straub, 1999). In this research, a
participant’s usage intentions were characterized by whether he/she would be willing to use the e-Portfolio system. Therefore, this research tests the following hypothesis:

H13: Attitude towards use will have a positive effect on the user’s intention to use the e-Portfolio.

System quality

DeLone and McLean (1992) proposed ISSM in which information quality and system quality are the two important antecedents of user satisfaction and use. Recently, McKinney et al. (2002) separated web site quality into information quality and system quality and explored customer satisfaction with a web site during the information search stage. Masoner et al. (2010) also claimed that information quality, system quality, perceived usefulness, and user satisfaction are criterion variables in information systems assessments. Therefore, this research tests the following hypothesis:

H8: System quality will have a positive effect on user satisfaction in using an e-Portfolio.

Information Quality

DeLone and McLean (1992) argued that information quality was important in building successful IS. Lin and Lu (2000) developed it as part of system quality and argued that its variables were useful predictors of user behavior. Beyah et al. (2003) measured perceived content quality and other constructs in assessing web-based systems. They found that perceived content quality was a significant determinant in their use. Jennex and Olfman (2006) included constructs for information quality in their knowledge management success model. Therefore, this research tests the following hypothesis:

H9: Information quality will have a positive effect on user satisfaction in using an e-Portfolio.

Service Quality

Developed in 1988, the SERVQUAL instrument proposed that perceptions of service quality are formed based on the gap or difference between a customer’s expectations of service quality and their perceptions of the delivery of that service and resulting satisfaction (Parasuraman et al., 1988). As for the relationship between service quality and user satisfaction, Pitt et al. (1995) and Landrum et al. (2010) suggested that service quality provides a superior indicator of user satisfaction and indicated that service quality can influence user satisfaction irrespective of whether a user interacts with one or multiple IS. This argument was supported by the revised IS success model (DeLone & McLean, 2003). Therefore, this research tests the following hypothesis:

H10: Service quality will have a positive effect on user satisfaction in using an e-Portfolio.

User satisfaction

User satisfaction has been employed as a surrogate for information system success and, therefore, is frequently been measured (Doll et al., 2004; Hsu & Lin, 2008). The conceptualization of customer satisfaction adopted here corresponds to the summary affective response or feeling a learner has in relation to her/his experience with all aspects of using the e-Portfolio system. Several researchers have indicated that the quality of technology significantly affects the level of satisfaction students take in e-Learning (Piccoli et al., 2001; Sun et al., 2008). New information and communication technologies and emerging learning models have triggered a new wave of educational innovation in the design of the learner experience in e-learning systems (Wu et al., 2008). Higher technology quality and greater user satisfaction will result in improved learning effects (Piccoli et al., 2001). Woods (2002) also suggests that both quality and quantity of interaction between the instructor and individual learners are much more crucial to the success of e-learning courses and student satisfaction than they are in traditional courses, and this interaction between instructor and learners could be arranged through an e-Portfolio environment. Based on the DeLone and McLean (2003) IS success model, user satisfaction may be assumed to be the determinant of net benefit or individual impact. Thus, our hypotheses are:

H12: User satisfaction will have a positive effect user attitude towards using an e-Portfolio.
H14: User satisfaction will have a positive effect on user intentions to use an e-Portfolio.
Methodology

Participants and data collection

Before conducting the major survey, a pre-test and a pilot test were performed to validate the instrument. Four respondents who were experts in the field of e-learning and e-Portfolios were selected to participate in the pre-test. Two respondents were e-portfolio development project managers from SUNNET and FormosaSoft, which have not only deployed e-learning systems at hundreds of universities and colleges, but are also pioneers in the development of e-Portfolio systems in Taiwan. The other two respondents were university instructors who have taught e-learning related courses and used e-Portfolio systems with their students for over five years. Thus, we have two experts from a development background, and two from an academic background. The selected experts were asked to comment on items that corresponded to the various constructs, including the wording of items, questionnaire format, and instrument length. To reduce potential ambiguity in the questions, a pilot test was conducted including 20 respondents, self-selected from graduate students in an e-learning community.

A total of 500 questionnaires were conducted within a university in central Taiwan; 435 were collected for a return rate of 84.7%. Nineteen questionnaires were excluded for incomplete answers, leaving 416 valid samples, for a valid response rate of 83.2%. The valid responses including 310 from males and 106 from females, 331 from undergraduate students and 85 from graduate students, 253 engineering majors, 113 business majors, and 50 science majors.

Measures

This research proposes an initial model illustrating the relationships among these factors in Figure 3. A questionnaire was designed consisting of sixty 5-point Likert-scale items grouped into five scales addressing these ten factors. The questionnaire began with an opening statement about the purpose of this research and a paragraph that explained the meaning of an e-Portfolio system. After reading these introductions, the participants provided demographic information and responded to questions reflecting the following ten scales.

User motivation was measured by 8 items adopted mainly from the scale proposed in Pintrich et al.’s (1989) MSLQ. The scale in this questionnaire has demonstrated good psychometric properties which can be used to investigate motivating strategies for learning attributes, thus tying into the purpose of this study. Previously, Davis et al. (1992) and Bhattacherjee (2000) had respectively examined human motivations underlying individual acceptance of e-mail and e-commerce services. Therefore, we adopted their scales and chose some items associated with user motivation as the measurement criteria.

Computer self-efficacy was measured by 7 items taken from Murphy et al. (1989) and Compeau et al. (2006). Murphy et al.’s (1989) CSES scale provided useful evidence that the perceptions students have of their potential to learn to effectively use computers effectively in the future significantly improved as a result of their training experience, which also satisfies the purpose of this study. Compeau et al. (2006) defined computer self-efficacy as "an individual's perception of his or her ability to use a computer in the accomplishment of a job task." We adopted the scales from these studies, and chose some items associated with computer self-efficacy as the means of measurement.

Perceived ease of use, perceived usefulness, and attitude were respectively measured by 5, 9, and 5 items adapted from the scales of Davis et al. (1989), Taylor & Todd (1995), and Teo et al. (2008). A brief literature review shows the scales of Taylor & Todd (1995), and Teo et al. (2008) attempt to measure the significant influences of the learner attitudes from the perspectives of perceived ease of use and perceived usefulness. We thus adopted their scales and chose some items associated with these three variables as the means of measurement.

System quality, information quality, and service quality were respectively measured by 4, 4, and 5 items mainly from DeLone & McLean's (2003) scale. Specifically, Jennex and Olfman (2006) and Masoner et al. (2010) also claimed that information quality and system quality are criterion variables in the assessment of information systems. Therefore, we adopted their scales and chose some items associated with these two variables as the means of measurement. Parasuraman et al. (1988) proposed the SERVQUAL scale to assess customer perceptions of service quality in service and retail businesses. Pitt et al. (1995) were among the first to adapt SERVQUAL to measure
service quality of IS functions. We thus adopted their scales and chose some items associated with service quality as the means of measurement.

*User satisfaction* and *intention to use* were respectively measured by 4 and 9 items, mainly from DeLone & McLean's (2003) scales. We adapted items from their scale because, according to ISSM theory, user satisfaction is the critical factor affecting user adoption of information systems. Davis et al. (1989), DeLone & McLean (2003), and Teo et al. (2008) also claimed that evaluating intent to use was the final goal for practitioners in terms of understanding the strategies that underlie user adoption of any information system. Therefore, we adopted their scales and chose some items associated with intention to use as the means of measurement.

**Assessing reliability and validity**

**Instrument reliability**

According to Wortzel (1979), a Cronbach's $\alpha$ coefficient between 0.7 and 0.98 indicates enhanced reliability. Following reliability analysis, Cronbach's $\alpha$ coefficient of intention to use (IU) reaches a high of 0.952. All dimensions are over 0.800 and, overall, Cronbach's $\alpha$ is 0.979, meaning that the questionnaire dimensions have a high degree of homogenous consistence and reliability to distinctively reflect the study's structural dimensions. Table 1 shows the detailed reliability coefficients.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Cronbach's $\alpha$ value</th>
<th>Cronbach's $\alpha$ based on standardized items</th>
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</thead>
<tbody>
<tr>
<td>User motivation (UM)</td>
<td>.871</td>
<td>.870</td>
</tr>
<tr>
<td>Computer self-efficacy (CSE)</td>
<td>.871</td>
<td>.871</td>
</tr>
<tr>
<td>Perceived ease of use (PEOU)</td>
<td>.911</td>
<td>.911</td>
</tr>
<tr>
<td>Perceived usefulness(PEU)</td>
<td>.948</td>
<td>.948</td>
</tr>
<tr>
<td>System quality(SQ)</td>
<td>.875</td>
<td>.876</td>
</tr>
<tr>
<td>Information quality (IQ)</td>
<td>.895</td>
<td>.895</td>
</tr>
<tr>
<td>Service quality (SVQ)</td>
<td>.899</td>
<td>.899</td>
</tr>
<tr>
<td>User satisfaction (US)</td>
<td>.912</td>
<td>.912</td>
</tr>
<tr>
<td>Attitude (AT)</td>
<td>.910</td>
<td>.911</td>
</tr>
<tr>
<td>Intention to use (IU)</td>
<td>.952</td>
<td>.952</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>.979</strong></td>
<td><strong>.979</strong></td>
</tr>
</tbody>
</table>

**Discriminant and convergent validity**

Convergent validity tests whether the correlations between measures of the same factor are different from zero and large enough to warrant further investigation of discriminant validity. Given the empirical results shown in Table 2, attitude (AT) and intention to use (IU) achieve a significant correlation ($r=.872, p<.001$), and service quality (SVQ) and intention to use (IU) also achieve a significant correlation ($r=.801, p<.001$).

<table>
<thead>
<tr>
<th></th>
<th>UM</th>
<th>CSE</th>
<th>PEOU</th>
<th>PU</th>
<th>SQ</th>
<th>IQ</th>
<th>SVQ</th>
<th>US</th>
<th>AT</th>
<th>IU</th>
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<tbody>
<tr>
<td><strong>UM</strong></td>
<td>1</td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>CSE</td>
<td>.415***</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PEOU</td>
<td>.489***</td>
<td>.577***</td>
<td>1</td>
<td></td>
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<td></td>
<td></td>
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<tr>
<td>PU</td>
<td>.659***</td>
<td>.393***</td>
<td>.635***</td>
<td>1</td>
<td></td>
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<td></td>
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<tr>
<td>SQ</td>
<td>.489***</td>
<td>.340***</td>
<td>.559***</td>
<td>.634***</td>
<td>1</td>
<td></td>
<td></td>
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<tr>
<td>IQ</td>
<td>.540***</td>
<td>.358***</td>
<td>.568***</td>
<td>.679***</td>
<td>.719***</td>
<td>1</td>
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</table>
**Results and pedagogical implications**

Figure 4 presents the properties of the causal paths, including standardized path coefficients, p-values, and variance for each equation in the hypothesized model. Besides, the direct, indirect, and total effects of dominants on intention to use are summarized in Table 3. From the perspective of direct effect, user attitude was directly affected by user satisfaction, perceived usefulness, and perceived ease of use. In addition, user satisfaction was direct affected by service quality, information quality, and system quality. The direct effect of user attitude on intention to use was 0.723. The direct effect of user satisfaction on intention to use was 0.188. From the perspective on indirect effect, the user motivation had the most significant influence on user attitude, user satisfaction, and intention to use. Finally, user attitude was the most important factor for intention to use followed by user satisfaction.

![Figure 4. Model testing results (*** p < 0.001, ** p < 0.01, * p < 0.05)](image)

The results made several key findings regarding the implications and determinants of e-Portfolios adoption on individuals. First, user personalities in the TAM and ISSM dimension were investigated. The results indicate that user motivation is positive and significantly associated with perceived ease of use ($\beta = 0.303, p = 0.000$), perceived usefulness ($\beta = 0.588, p = 0.000$), system quality ($\beta = 0.401, p = 0.000$), information quality ($\beta = 0.467, p = 0.000$), and service quality ($\beta = 0.483, p = 0.000$). Thus, $H_{1-a}, H_{2-a}, H_{3-a}, H_{4-a}$ and $H_{5-a}$ are supported. In addition, computer self-efficacy is also positively and significantly associated with perceived ease of use ($\beta = 0.446, p = 0.000$), perceived usefulness ($\beta = 0.156, p = 0.000$), system quality ($\beta = 0.134, p = 0.006$), information quality ($\beta = 0.166, p = 0.000$), and service quality ($\beta = 0.170, p = 0.000$). Therefore, $H_{1-b}, H_{2-b}, H_{3-b}, H_{4-b}$ and $H_{5-b}$ are fully supported.

In TRA- or TAM-related literature, these external variables were typically investigated in situations in which users were already using a system (Tzeng, 2011). In contrast, this research was conducted on subjects prior to their having any hands-on experience with an e-Portfolio system, and their intrinsic/extrinsic motivation and system operation ability regarding the use of e-Portfolio system can substantially influence their attitude towards and satisfaction with
the e-Portfolio system. Therefore, our proposed model is in line with Legris et al. (2003) who suggested the TAM should include social or behavior variables. The explanation for this may be justified by motivational theory. According to Bandura’s (1994) social motivational theory, higher self-efficacy results in a more active learning process. In this research, we adopted user motivation and computer self-efficacy as external variables and thus improved our ability to explain the intention to use the e-Portfolio system.

Table 3. Direct, indirect, and total effect of dominants on intention to use

<table>
<thead>
<tr>
<th></th>
<th>Direct effect</th>
<th>Indirect effect</th>
<th>Total effect</th>
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<tbody>
<tr>
<td></td>
<td>AT US IU</td>
<td>AT US IU</td>
<td>AT US IU</td>
</tr>
<tr>
<td>UM</td>
<td>-- -- --</td>
<td>.507*** .409***</td>
<td>.444*** .507*** .409*** .444***</td>
</tr>
<tr>
<td>CSE</td>
<td>-- -- --</td>
<td>.258*** .143***</td>
<td>.262*** .258*** .143*** .262***</td>
</tr>
<tr>
<td>PEOU</td>
<td>.124*** --</td>
<td>.293*** --</td>
<td>.212*** .417*** -- .212***</td>
</tr>
<tr>
<td>PUC</td>
<td>.388*** --</td>
<td>-- --</td>
<td>.281*** .388*** -- .281***</td>
</tr>
<tr>
<td>SQ</td>
<td>-- .162***</td>
<td>-- .075***</td>
<td>-- .085*** .075*** .162*** .085***</td>
</tr>
<tr>
<td>IQ</td>
<td>-- .296***</td>
<td>-- .138***</td>
<td>-- .155*** .138*** .296*** .155***</td>
</tr>
<tr>
<td>SVQ</td>
<td>-- .427***</td>
<td>-- .199***</td>
<td>-- .223*** .199*** .427*** .223***</td>
</tr>
<tr>
<td>AT</td>
<td>-- .723***</td>
<td>-- --</td>
<td>-- -- --</td>
</tr>
<tr>
<td>US</td>
<td>.465*** --</td>
<td>-- .188***</td>
<td>-- -- .336*** .465*** -- .524***</td>
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* p < 0.05, ** p < 0.01, *** p < 0.001

Second, the results between the TAM dimensions (including perceived usefulness and perceived ease of use) and user attitudes were discussed. The results show that user attitudes toward using e-Portfolios is positively influenced by the perceived ease of use ($\beta = 0.124$, $p = 0.000$) and perceived usefulness ($\beta = 0.388$, $p = 0.000$). Thus, $H_6$ and $H_7$ are supported. In addition, these two factors explain 75% of the variance in user attitude. The results show the perceived usefulness has the highest direct impact on user attitudes, followed by perceived ease of use. Learners who respond more positively for perceived usefulness and perceived ease of use are more willing to participate and fondness of e-Portfolio. The result corresponds with findings from Taylor and Todd (1995), Teo et al. (2008), and Miller et al. (2010). Similarly, perceived ease of use also has a significantly positive relationship with perceived usefulness ($\beta = 0.635$, $p = 0.000$). Therefore, $H_{11}$ is supported. As the result, the perceived ease of use has a positive influence on perceived usefulness, consistent with findings from Igbaria et al. (1995), and Lederer et al. (2000).

Furthermore, both perceived usefulness and perceived ease of use have a significant indirect effect on behavioral intention to use e-Portfolio. In the proposed model perceived ease of use has a higher total effect on attitude than does perceived usefulness. However, according to the original TAM, perceived usefulness is hypothesized to affect intention to use, and perceived ease of use is not hypothesized to indirectly affect intention. The results showed user attitudes only partially mediated the effects on intention to use. The perceived usefulness of this research was consistent with previous research, whereas perceived ease of use and user attitudes were contrary to previous results. One possible explanation is that, given the rich e-learning systems and emerging technologies currently available, learners may choose a tool that emphasizes ease of use to raise the speed and efficiency of their learning. Thus, these factors affected users’ attitudes towards e-Portfolios, which fully affected their intention to use.

Third, the relationships between the ISSM dimensions (including system quality, information quality and service quality) and user satisfaction were analyzed (see Fig. 4). The results show that user satisfaction is positively influenced by system quality ($\beta = 0.162$, $p = 0.000$), information quality ($\beta = 0.296$, $p = 0.000$), and service quality ($\beta = 0.427$, $p = 0.000$). In addition, these three factors explain 65% of the variance in user satisfaction. As a result, $H_8$, $H_9$, and $H_{10}$ are supported. In terms of direct effect, we found service quality has the greatest impact, followed by user information quality. In addition, an e-Portfolio learning platform that provides useful, correct, and rich information for learners will have a more positive impact on learner satisfaction. In terms of indirect effect, we found user motivation has the highest impact on user satisfaction. More positively motivated learners are more willing to participate in the e-Portfolio learning environment. These results correspond with findings from Amoroso and Cheney (1991), and Igbaria et al. (1995).
Lastly, the three critical dimensions, including attitude, user satisfaction, and intention to use were examined. In our analysis, we found intention to use is significantly affected by attitude ($\beta = 0.723, p = 0.000$) and user satisfaction ($\beta = 0.465, p = 0.000$), and these two factors explain 77.4% of the variance in intention to use. Thus, H$_{12}$ and H$_{13}$ are supported. As the result, we investigate the intention to use and its relationship with other dominants. In terms of the TAM dimensions in this research, perceived ease of use, perceived usefulness, and use attitude have a positive influence on intention to use. Attitude has the highest impact, followed by perceived usefulness. Learners with more positive responses for attitude, participation willingness and fondness for the e-Portfolio system, they are more willing to recommend it to other people. The results correspond with Davis et al.’ (1989) finding that attitudes strongly mediate the effects of beliefs on intention. In terms of the ISSM, system quality, information quality, service quality and user satisfaction have a positive impact on intention to use. Service quality has the greatest impact, followed by user satisfaction. In terms of attitude to use, service quality has the greatest impact and positively affects attitudes. The result reinforces DeLone and McLean’s (1992) finding that service quality will impact user satisfaction and intention to use the information system. Finally, user satisfaction is positively and significantly associated with intention to use e-Portfolios ($\beta = 0.188, p = 0.000$). Thus, H$_{14}$ is supported. Thus, a e-Portfolio learning platform that satisfies learners’ needs, fosters a more positive learning attitudes in the users. These results correspond with DeLone and McLean’s (2003) findings.

**Conclusion and limitations**

Our research is an empirical effort to examine factors affecting intention to use an e-Portfolio system. Thus, the results represent an important step in unraveling the intricate relationship between the key constructs. This research made several key findings regarding the implications and determinants of individual adoption of e-Portfolios: (1) The traditional conceptualization of TAM and ISSM were successfully applied in an investigation of e-Portfolio systems. (2) Among the determinants, perceived usefulness had a higher direct influence on user attitudes toward adopting e-Portfolios than did perceived ease of use. (3) Among the determinants, service quality was the most directly influential factor affecting user satisfaction with e-Portfolios. (4) Among the determinants, attitude was the most influential factor affecting the adoption of e-Portfolios, followed by user satisfaction. (5) This research found that these two significant determinants of e-Portfolio adoption (i.e., user motivation and computer self-efficacy), had seldom been explored in prior research on IT adoption, despite user motivation being the most indirectly influential factor affecting the adoption of e-Portfolios. Thus, the findings of this research are valuable and provide several important implications for research into the adoption of e-Portfolios and in practice.

Our research has implications for research and practice that could be helpful for improving university students’ behavioral intention to use e-Portfolios. First, there is potential for practical applications in the development and management of e-Portfolios on campus. Educators and managers should make an effort to promote students’ computer self-efficacy through on-line and off-line support which could take the form of handbooks, and strategy guides for using e-Portfolios. Second, user motivation is the most important factor affecting both behavioral intention and attitudes towards e-Portfolios. In Taiwan, IT plays a role in peoples’ daily lives and people are accustomed to social change prompted by technological innovations. If students think that e-Portfolios can assist them in learning and career development, they will be willing to use them. Moreover, students who don’t use e-Portfolios may come to fear falling behind their classmates who do. Therefore, university must emphasize e-Portfolio use by offering a greater variety of e-Portfolio training courses, developing a complete e-Portfolio performance evaluation, and promoting the benefits of e-Portfolios among students.

Finally, even though perceived usefulness, ease of use, and service quality had no direct effect on intention to use e-Portfolios, these factors has a significantly influence on the user attitudes and user satisfaction toward e-Portfolios. Thus, managers and developers should help students increase their positive perception of e-Portfolios through user-friendly design and user-oriented content. This solution improves the service quality of personal learning preferences through the use of e-Portfolios, thus enhancing user satisfaction and resulting in a more positive user attitude which, in turn, encourages students to further engage with e-Portfolios.

This empirical study has several limitations. First, sampling was taken only from students in a university in central Taiwan, which had implemented e-Portfolios for several years. We recommend that the study scope be expanded to
other colleges/universities to avoid concerns based on the limitations of the sample. Second, factors affecting user behavior are complicated and diverse. There are still other factors affecting intention to use and actual use that have not been taken into consideration, including user involvement, perceived pleasure, etc., and further analysis and study is recommended. Third, other models, such as the innovation diffusion model could be included to enhance explanatory capacity and raise the comprehensiveness of the study.

References


The Searching Effectiveness of Social Tagging in Museum Websites

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ABSTRACT
This paper explores the search effectiveness of social tagging which allows the public to freely tag resources, denoted as keywords, with any words as well as to share personal opinions on those resources. Social tagging potentially helps users to organize, manage, and retrieve resources. Efficient retrieval can help users put more of their focus on studying the resources rather than the retrieval process. This study was an investigation into the relations between social tags and user queries. Our findings were summarized into 4 main points: 1) 85% of the surveyed users agreed that social tags assisted them in searching for resources; 2) Over 40% of user queries searches, found their resources via the matching of social tags; 3) Social tags matched over 70% of user queries; 4) 14% of the social tags for a resource did not appear in the context of the resource. The experimental results demonstrated that social tags can improve users’ efficiency in searching for resources.

Keywords
Social tagging, Search effectiveness, Web 2.0, Museum websites, Educational resources

Introduction
This paper explores the effects of social tags (O’Reilly T., 2005) on searching educational resources of science museum. Social tagging is a component of Web 2.0 (O’ Reilly T., 2005), which has been recognized to have potential in helping users organize, manage, and retrieve resources (Heckner et al., 2009; Churchill et al., 2009; Rainie, 2007; Bateman et al., 2007; Maggio et al., 2009).

Science and technology development have become key indicators of national competitiveness. Nurturing talents of science and technology through innovative science education is one of the most important goals to ultimately raise Taiwan’s national competitiveness (White Paper on Science and Technology of the Republic of China, http://web1.nsc.gov.tw/public/Attachment/012292110371.PDF). Science fair events provide a specific educational opportunity to learn, understand, apply, provide real experiences, and develop skills in terms of science topics (SCIENCE FAIR GOALS, 2011). The Intel International Science and Engineering Fair (Intel ISEF), which stems from the National Science Fair, http://www.societyforscience.org/isef/) is the largest annual international pre-college science competition worldwide. For Taiwan, a total of 181 Taiwanese students have participated in Intel ISEF since 1982 and 71% of the participants have brought home a prize (http://www.ntsec.gov.tw).

The National Taiwan Science Education Center (NTSEC) is the largest science center in Taiwan, and it is largely responsible for the promotion science education in primary schools, secondary schools as well as for the general public. NTSEC has exhibited 5065 digital documents of science fair projects which were collected from national elementary, junior high, senior high, vocational school, and international science fair events. One function of the NTSEC is to enable the successful retrieval and learning of its science fair exhibitions (Schatz, 1997; Kilic-Cakmak, 2010, Thamaraiselvi, 2009; Gilliland-Sweetland & White, 2005).

NTSEC provides multiple ways for users to retrieve its exhibitions. Users can specify keywords as a query, and then allow the system query to match the metadata or/and text of the science fair documents. The output is the collection of documents of which metadata or/and text is matched to the query. The most popular searching methodology is the full-text searching which matches queries including both the metadata and text. Alternatively, users can browse the resources via directories. The digital repository’s directories were created based on field (nature, mathematics, physics & chemistry, and so on), published year, type of award, and school level of science fair projects.
Recently, Web 2.0 based applications (such as YouTube, Facebook, Del.icio.us, and Wikipedia) have led to an increase of popularity especially among younger groups of internet users (Godwin, 2006; McLoughlin & Lee, 2007). Web 2.0, learning would induce a higher level of user’s self-efficacy (http://en.wikipedia.org/wiki/Self-efficacy), which leads to a higher performance in dealing with learners’ tasks (Bandura et al, 1982; Oliver & Shapiro, 1993). To this end, we have built a social tagging platform on the digital science fair repository. Social tagging allows users to tag resources with any words, denoting as keywords to share personal opinion on the resources. Tags can be used to bookmark and organize personal favorite resources. They also can be shared via browsing and searching, which makes the tagged resources retrieved by others.

The Potential benefits of social tagging to digital libraries or data collections of websites have been addressed in a number of papers (Heckner et al., 2009; Noruzi, 2006; Churchill et al., 2009; Rainie, 2007; Bateman et al. 2007; Maggio et al., 2009; Furner et al., 2006). From these studies five main benefits of social tagging become apparent:

- By social tagging, resources are tagged from the viewpoint of the public, who categorize them by a familiar and sharable vocabulary. This enhances the search effectiveness in terms of recovering and discovering of resources (Heckner et al., 2009; Noruzi, 2006; Churchill et al., 2009; Rainie, 2007; Furner et al., 2006).
- Social tagging facilitates the connection of user group with similar interest and expertise (Bateman et al., 2007; Rainie, 2007; Noruzi, 2006), which would enable context of collaborative learning (Terntin, 2008; Rubio et al., 2009).
- Social tagging is the on-going process of making sense of things collaboratively made by users (McLoughlin and Lee, 2007; Rainie, 2007). This provides an opportunity for users to summarize new ideas through viewing others’ tags (Bateman et al. 2007; Maggio et al., 2009; Furner et al., 2006).
- Social tags reflect personal preference of organizing resources (Bateman et al. 2007; Rainie, 2007). Analyzing these tags would enable further exploration of personal scientific literacy or interests on the scientific facets.
- Social tagging has the potential to be complementary to professional classification schemes such as Dublin Core (http://dublincore.org), IEEE LOM (http://ltsc.ieee.org/wg12/20020612-Final-LOM-Draft.html) and LCSH (http://www.hahlibrarity.net/libraries/formgenre.html). For example, social tagging can efficiently reflect emerging nomenclature which has hardly kept pace with professional classification schemes (Tennis, 2006; Furner et al., 2006; Trant, 2008; Yi et al., 2009).

While the benefits of social tagging are appreciated, social tagging is not without problems. These problems include: polysemy (a term has two or more similar meanings), synonymy (different terms have similar or identical meanings), and lack of hierarchy ambiguity (how specific should resources be described), which are mainly recognized the absence of characteristics of professional classification schemes (Noruzi, A., 2006; Macgregor & McCulloch, 2006; Golder & Huberman, 2006).

This paper focuses on the retrieval effectiveness of social tags. Efficient retrieval is both a goal of museums to operate their websites (Thamaraiselvi, 2009; Gilliland-Swatland & White, 2005) and a demand of a wide range of Internet users to visit museum websites (Kravchyna & Hastings, 2002; Ockuly, 2003). Efficient retrieval can help users put more of their focus on studying the learning resources rather than the retrieval process (Kilic-Cakmak, 2010; Schatz, 1997). Despite many investigations done on social tags over different systems (Farooq et al., 2007; Marlow et al., 2006; Golder & Huberman, 2006; Yanbe et al., 2007; Heymann et al., 2008; Yi et al., 2009; Trant, 2008; Bischoff et al., 2008), studies are lacking in terms of social tagging retrieval efficiency.

Almost of priori works focused on the maturity and statistics of social tags but less explorations on the enquiry of social tags issued by users. In addition, most of the systems examined only provide the retrieving manners of which indexing terms are tags. There is no alternative choice for users to retrieve. This would overstate the soundness of social tags. On the other hand, the data of our system is already presented, which is different from that of most of those examined in the previous works that were contributed by users. This would bring “new motivations for social tagging since users are no longer tagging the content that they produce, but rather predefined content already available on the site” (Zollers, 2007). Moreover, the community on our system is comprised of mainly students and teachers, which can be very different from those of other general purpose systems, which are regularly composed of the general public. This would present different aspect from that of other systems.

In our system, users retrieved resources via full-text searching or searching by the matching of social tags. Note that, full-text searching ignored the “social tag metadata.” Upon such circumstance, we investigate the statistics where users employed social tags to search for resources. We supposed that if users recognized that social tags could help
them search for resources, they were likely to search for resources via the help of social tags. We also examined the context of social tags against that of the tagged resources as well as user queries. This helped us to reveal the vocabulary of general public itself in terms of the differences between tagging and querying. This also helped us to explore the difference between the vocabulary of general public and that of used to describe those documents originally. For the later, we aimed at recognizing whether social tags could bring novel expressions to the tagged documents. In addition, a number of users were surveyed regarding their perception on social tagging. Our results indicated that social tags do assist users in resource retrieval.

**Literature survey**

Learning in museums meets the context of informal settings such as non-directed, exploratory, voluntary, and so on which are different in many aspects from learning inside schools (Wellington, 1990; Hofstein & Rosenfeld, 1996). Over the years, evidences have shown that museum learning is able to enhance visitors’ cognitive, psychomotor, and affective in terms of the various educational subjects (Kropf, 1989; Griffin, 1998; Falk & Dierking, 2000). Museum websites provide remarkable educational possibilities and attract wide range of Internet users, including school students, researchers, and the general public (Corredor, 2006; Jones-Garmil, 1997). The online features exhibited and the ways presenting these features may influence the usability of museum websites to a vast number of Internet users. Laurillard (2002) classified the resources on museum websites into five levels of cognitive to users. The highest two cognitive levels of resources enable visitors to responding, expressing, and presenting their cognition regarding the resources. Later, Brown (2006) pointed out most of museum websites commonly lacked of those media with higher level of cognitive and suggested museums need to consult those media to accumulate wide range of cognitive learning experiences. Social tagging enables people to express any of their opinions to the resources presented. Via the connection of social tags, people can build their own communities, and thus could derive further opinion exchange and communication between them. Marty and Twidale (2004) conducted 36 various types of museum websites and then outlined five general categories representing different characteristics of user usability problems. One category was that “museum websites are designed by museum professionals.” Museum professionals often design websites that use controlled vocabularies unfamiliar to “non-museum professionals” (Marty & Twidale, 2004). Social tags are made by the users themselves and are as such naturally more familiar to users than the controlled terms (Macgregor & McCulloch, 2006). Kravchyna & Hastings (2002) and Ockuly (2003) investigated user motivations to visit museum websites. Some main motivations were to search for a museum collection or to find information on special events in the museum for learning, research, or class assignment. Regarding the general purpose that people issue an Internet search, Rose & Levinson (2004) found that about 86% of Internet users were to obtain a resource and learn something new available on websites.

The motivations of why users tag would affect the content of social tags. Marlow et al. (2006) realized that a tag can be given derived from one or multiple motivations which are for the purpose of personal future retrieval, contributing personal idea and expressing personal opinion, attracting others’ attention including leaving personal identity information, and just being asked to add tags. Heckner et al. (2009) found that personal information management and sharing are the two main motivations for users to tag resources in general. The result shows that personal information management is more general for the users in Del.icio.us and Connotea (http://www.connotea.org/) while personal information sharing is more general for those in YouTube. Based on our observation, the user motivation of a website may respond to motivational design of the website. For example, as the title of YouTube is “YouTube—Broadcast Yourself,” the website explicitly encourages users to publish and share their data.

Golder & Huberman (2006) identified several functions of tags to the tagging resources. Tags can be used to express the topics of resources, things about the resources, owners of the resources, categories of the resources, and qualities (or characteristics) of the resources. In addition, tags were specified for personal reference or task being performed. Bischoff et al. (2008) classified tags into different categories and found the tag distribution among Del.icio.us (http://www.delicious.com), Flickr (http://www.flickr.com), Lastfm (http://www.last.fm), and sets of anchor texts (clickable text with a hyperlink connection) were very different.

Some of recent studies investigated the quality, usefulness, and meaningfulness of social tags. Based on studies done on CiteULike (http://www.citeulike.org), Farooq et al. (2007) recognized that the growth of new tags and new users grow at a linear rate and are correlative to each other. This would enable a probability that more and more new tags will be assigned to the same resource over time. As a result, a pool of diverse social tags would lead to a higher
discovering probability of the tagged resource. Focusing on the tags of particular resource, Golder & Huberman (2006) found that the frequency of most tags will reach stable after a few number of users bookmarking that resource. Such phenomenon may support the hypothesis that user’s perspectives on resources will be sufficiently expressed with the passage of time via collaborative tagging. Nevertheless, in most of social tagging systems, tags of a resource provided by other users were used to suggest another one to tag the resource. This would restrict the mind of the user to describe the resource. As a result, the user would tend to select the terms what others have tagged to tag the resource.

Yanbe et al. (2007) denoted the popular tags (a set of most recently used tags) of del.icio.us as queries. They then searched the results of the queries from del.icio.us and Google. They found that a high number of pages would be placed in the back of the answer pages of Google (less noticed by Google). In addition to general search engine, del.icio.us would provide an alternative approach of retrieving web resources. Heymann et al. (2008) investigated the characteristics of both taggers and tags on del.icio.us. The investigations can be classified into positive and negative aspects. Regarding positive aspects, the authors found 25% of the pages in del.icio.us could not be retrieved from Yahoo. About 40% of web pages tagged were newly added in del.icio.us. Regarding negative aspects, the scale of pages posted in del.icio.us were relatively small compared to that of pages existing on the entire Internet. Moreover, about 76% of tags of a page appeared in the context of the pages. Bischoff et al. (2008) pointed out users in del.icio.us, Flickr, and Lastfm preferred to use a few common tags to tag resources. Moreover, after comparing the anchor texts and tags of the same web pages, over 50% of tags do not appear in the anchor texts.

Yi and Chang (2009) compared popular tags of del.icio.us with Library of Congress Subject Headings (LCSHs). They found that the about two-three of social tags appeared in LCSHs. They noticed that most of technology-related tags were not found in LCSHs, which is generally recognized that updating and revising professional classification schemes is time consuming (Kroski, 2005; Tennis, 2006; Furner et al., 2006; Trant, 2008). Trant (2008) studied the relationship of social tags of an online art collection to the documentation created for the art collection. He found that 86% of tags did not appear in the documentation, indicating that the vocabulary between public and professors are significant different.

Some approaches have embedded social tagging functionalities into libraries or in-campus systems. Dahl et al. (2008) introduced the social tagging embedded e-learning system share.loc which is used in the campus of Muenster University. The main indexing of the resources is the IEEE LOM with an extendable metadata field LOM:Classification:Keyword which places the keywords originally given by authors and the user added tags. Churchill, et al. (2009) proposed the RISAL, Repository of Interactive Social Assets for Learning, which was implemented based on Web 2.0 techniques including social tagging functionalities. RISAL has been successfully used by teachers and students of the University of Hong Kong. Kalamatianos et al., (2009) introduced the ASK-LOST 2.0 which provides social tagging functionalities on digital educational resources.

Maggio et al. (2009) utilized the student specified tags to assist a course teaching, which aims at how to retrieve and manage biomedical literature. The controlled vocabulary Medical Subject Headings (MESH) is used to index the biomedical database MEDLINE (http://www.nlm.nih.gov/databases/databases_medline.html). In the course, students were asked to study MEDLINE and finally able to specify and recognize appropriate MESH terms to gather the intended resources from MEDLINE. For the first assignment of the course, it presented students with a MEDLINE’s paper with a set of multimedia digital resources related to the paper, and then asked students to tag the paper. The student’s tags were denoted as the connection between MESH and the student’s vocabulary. These tags were then utilized to demonstrate different concept levels of MESH built on MEDLINE, which were difficult to explain. In the end of the course, students were again asked to tag the paper. The result showed that over 78% of the tags were the MESH terms associated with the article in MEDLINE. This indicates the study of MESH can be improved assisted in student’s tags.

**Methodology**

*The social tagging platform*

In February 2010, the social tagging platform was built on NTSEC’s science fair digital repository. On the social tagging platform, once a user logs in as a member, he/she can bookmark any science fair document(s) by using tags.
A user’s tags can be visible or invisible to other users. A user can search documents by matching query keywords to the visible tags. We call this kind of retrieving manner the **tag query**. In addition, a set of tags called **tag cloud** (http://en.wikipedia.org/wiki/Tag_cloud) is presented. Tag cloud constitutes of frequently tagged and recently retrieved tags. Users can browse the documents indexed by the tag cloud.

Figure 1 shows a portion of the main page of the science fair repository. There are three areas marked in which A, B, and C are respectively the tag cloud, full-text and tag query specification bars. Figure 2 presents the answers of a Chinese tag “正負二度C” by performing tag query. The general presentation of the tag is “±2℃” which is the title of a 2010 documentary film talking about global warming. “正負二度C” is a new term to Taiwanese regarding global warming since 2010. However, there are many science fair documents that were tagged with this tag where all of these science fair documents were written before 2010 (the context of these science fair documents do not contain “正負二度C”). In Figure 2, for briefly, we only list three matches of “正負二度C”.

![Figure 1: The main page of the science fair repository](image1)

![Figure 2: Three matches of the tag query “正負二度C”](image2)

**Research procedure and participants**

To promote the social tagging platform, an activity which encourages users to specify social tags began on 2010/5/15 and ended on 2010/6/15. Since the social tagging platform was built, all the social tags were collected and stored. As of October, 2010, we have collected 18,814 tags with a total of 6,530 unique tags. There were 2,694 science fair documents tagged, which occupies 53.2% of the total documents in the repository. All full-text and tag queries were also collected. We did a series of analysis across the collected tags, the science fair documents, and the user queries. Specifically, the context of tags and the corresponding science fair document were compared. Moreover, the amount of tag queries and social tags appearing in user queries were counted.

To further realize users’ perception on social tagging, during the activity period, a questionnaire was released; it consisted of 22 inquiries which questioned users’ perceptions on social tagging, social tagging related functionalities, user interface, and other functionalities of the repository. Users were asked to fill in the questionnaire and had to respond the questions mostly by expressing their agreement or disagreement on a 5 point Likert scale (5 is complete agreement and 1 is complete disagreement.) Eventually, there were total 86 users answered the questionnaire (47 female, 36 male and 3 unspecified). Each of surveyed users has used the science fair document repository. The job distribution of the 86 users were: teachers (27 users), students (23 users), and others (36). The Cronbach alpha for this questionnaire was 0.845, which means high reliability.

**The analyzed results**

**Observation 1:** In average, there were about 76% of the tags of a science fair project that appear in the corresponding document. Most of these tags were related to the subject of the project.
In the repository, a science fair document corresponds to a science fair project. The metadata, research procedure, and experiments of the project were all documented. The context of a document includes the text in title, authors, advisors, institution, keywords, abstract, and the main body of the science fair project. We call the research procedure and experiments of the project the main body of the project. We call the tags appearing in the context of the document the *in-context tags* while others the *out-context tags*. In average, there about 76% of the tags of a project were in-context tags. We found that only 0.4% of the in-context tags appear in the fields of authors, advisors, and institution, which are not related to the subject of the science fair project. Almost of the in-context tags were in the fields: keywords, the abstract, and the main body, which are related to the subject of the project. We also compared the keywords with tags and then found only half of the in-context tags are in the set of keywords. The keywords were the short summary of the science fair project. The social tags could be regarded as the public specified keywords. Therefore, the in-context tags which were not matching the keywords were new keywords of the project. In a conclusion, on average, approximately 32% of social tags summarized the project using different terms from the keywords originally given by the authors. These tags provided alternative view points to the project. In addition, most of the tags were related to the subject of project, which indicates social tagging could be applied to outline non-text presented media, such as documentary film, flash drama, and figure.

**Observation 2:** There were about 14% of the social tags of a science fair project that did not appear in the corresponding document. These tags provided additional information for the project.

We further analyzed the distribution of the 14% tags in sets of tags of other documents, formal science terms denoted as the indexing of the text books for junior high and senior high schools, and the yahoo news during 2010/1/1~2010/10/31. As shown in Figure 3, about 1/3 of out-context tags appear in yahoo news and only about 10% tags appeared in the set of formal science terms. This shows that some users tag resources by using informal science terms or general terms (i.e., they appear in yahoo news). On the other hand, approximately 36% of out-context tags appeared in the tag sets of other projects. This reflects the classification ability of social tagging naturally. For example, the tag “正負二度 C” (Figure 2) often appears in yahoo news and does not appear in the context of any science fair documents. However, it is the top-6 tags that are most frequently used by users to tag resources.

![Figure 3](image-url)  
*Figure 3. Distribution of out-context tags for a science fair document*

**Observation 3:** At least 40% of queries were tag queries. This reveals that there were a certain number of users likely to search science fair documents by matching tags.

One way to realize whether social tags can help users to search in the repository is to examine the user querying behavior. If users are willing to search documents by tag query manner, it would express the fact that social tags can help users retrieve the intended sources. In the repository, the full-text query is the most popular query manner for users to search science fair documents before introducing social tags. Therefore, we were interested in how users perform both full-text and tag queries interactively after introducing social tags. Figure 4 shows the frequency of both query types performed. In the figure, each point of a curve stands for the frequency of a query type performed in
a month. Note that, since social tags were introduced after January, 2010, we do not have the corresponding statistic before February, 2010. As shown in the figure, in the first four months (2010/2–2010/5), the frequency of tag queries was lower than that of full-text queries. In June, 2010, the frequency of tag queries reached a peak, which was more significant than that of full-text queries. The reason why the tag query frequency dramatically increased in 2010/6 may due to the activity promoting social tagging. After June, the frequency of tag queries went down. In the last two months, the frequency fell to less than that of full-text queries. A possible reason why the tag query frequency was less than that of full-text query may be due to the fact that only about 50% of total science fair documents were tagged. This would discourage users to employ tag query to search documents. Therefore, we believe that once all the documents are well tagged, the frequency of tag query would increase accordingly. Figure 5 further shows the percentage of each query type performed in the ration of total queries performed. As we can see, despite the reduction in frequency of tag queries in the last few months, it occupied approximately 40% of the total queries. This indicates that there were a certain number of users who were used to using tags to search documents.

**Observation 4:** Over 98% of tag queries matched some of social tags. This shows that user vocabulary is similar in the specifications of both tag querying and tagging.

An alternative way to evaluate the retrieval ability of social tags is to examine whether tags are often matched by queries. Figure 6 shows the ratio of both type queries per month matching some of tags. As shown in the figure, the ratio of tag queries per month was very high. A probably explanation is that the users who employ tag queries seem to know how to specify keywords to find documents. This can be further inferred that users use similar vocabulary to specify queries and tags. As a result, the intended resources would often be retrieved by tag query manner. In total, about 70% of queries (both types of query) matched social tags. This shows that in addition to searching the context of science fair documents, social tags significantly provide another way for users to find resources.

**Observation 5:** For the documents retrieved by those queries matching social tags, about 26% of the documents were retrieved via matching the out-context tags. Out-context tags can help users retrieve resources.
Followed by Observation 4, an advanced question thus arises. Can the out-context tags elaborate their function? That is, do the out-context tags really provide new resources for users when they search for the repository? To answer this question, the full-text queries matching social tags (about 50% of the full-text queries per month.) were selected to retrieve documents by tag query manner. The answer document set of these full-text queries and those of tag queries (the queries originally specified for tag query manner) were then analyzed. Figure 7 respectively shows the ratios of the two answer document sets regarding the documents which were retrieved via matching the out-text tags. On average, the ratios for full-text and tag queries were 14% and 40% per month, respectively. In general, for a query of those matching social tags (70% of the whole queries), about 26% of answers of the query were retrieved by matching the out-context tags. In summary, via the help of out-context tags, users are able to retrieve more resources.

**Observation 6:** The questionnaire shows that about 85% of users agree social tags can help them to search for resources.

Table 1 shows a portion of the questions and the corresponding results. These questions are directly related to social tagging. Generally, about 85% of users agree that social tags can help them to search documents (question 5.) In addition, based on the results of questions 1 and 2, most users agreed that tags can help them manage resources. In a social tagging system, users bookmark resources by their own vocabulary, and thus for themselves, it was easier to recover and classify resources. In addition to the fact that most of the tag queries could find answers, the high score for question 3 also implies that the returned answers were often the resources that users needed. This again shows that the vocabularies used by users to specify queries and tags are very similar. On the other hand, in a social tagging environment, some implicit concepts would be easier to discover though the use of collaborative tagging. Such concepts may appeal to users (Marsland, 2003). Question 4 reveals this viewpoint that about 75% of users would be interested in the resources that were not expected to appear in the answer set.

<table>
<thead>
<tr>
<th>Num.</th>
<th>Question</th>
<th>Avg. score</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Tags can help me faster recover the retrieved documents</td>
<td>4.29</td>
</tr>
<tr>
<td>2</td>
<td>Tags can help me classify documents</td>
<td>4.29</td>
</tr>
<tr>
<td>3</td>
<td>Tags can help me find the intended documents</td>
<td>4.18</td>
</tr>
<tr>
<td>4</td>
<td>Tags can let me find interesting documents accidentally</td>
<td>3.77</td>
</tr>
<tr>
<td>5</td>
<td>In a total, social tags can help me search documents</td>
<td>4.22</td>
</tr>
</tbody>
</table>

**Conclusion and future work**

Successful retrieval of user intended resources is a key issue for museum websites and digital libraries (Schatz, 1997; Kilic-Cakmak, 2010, Thamaraiselvi, 2009; Gilliland-Swetland & White, 2005). This paper studies the search effectiveness of social tags on NTSEC’s digital science fair repository. As shown by the experimental results, social tags can help users search their intended resources from the repository. Our analysis can be summarized as follows. 1) Above 40% of queries are tag queries. This shows that there are a number of users who realize tags can help them find intended resources and then are willing to search resources by querying tags. 2) About 14% of the social tags for a resource are out-context tags. These tags bring new information for users regarding the resource. The analysis also showed that social tags can be matched by over 70% of total queries. This states the user vocabulary is similar in the specifications of both query and tag. 3) To continue from the above statement, for those resources retrieved by the 70% of total queries, 26% of those resources were retrieved by matching the out-context tags. This reveals out-context tags are valuable for users to find the resources of which context does not contain the query keywords. 4) The user survey showed that roughly 85% of users agreed that social tags can help them search and manage resources. 5) Most of the tags are related to the subject of resources. This indicates that social tagging has the potential to describe other educational resources which are not presented in text.

In the NTSEC’s science fair repository, only half of the resources were tagged. Once all the resources are tagged, users could discover more resources via tag query. To gather more tags, we are planning to issue alternative activity to encourage users to tag those resources not yet tagged. We can also keep the list of resources retrieved by a user. If the user rarely tag, our system will automatically send a message to the user, explain the benefits of social tags, and then asks the user to contribute tags to the resources of the list. We are also considering auto-tagging technology.
The aim of auto-tagging is to automatically assign appropriate keywords for a resource. In principle, the appropriate keywords can be selected from the context or tag sets of other resources of which contents are similar to that of the resource.

For further future directions, we are especially interested in the discovery of relationships between user profile and behavior log on the system, context of tags, as well as that of documents. Discovering these relationships could help us realize why users tag, how users employ tags, user preference in using our system, and the connection between tags and the subject of the corresponding tagging documents. Implementing these features could facilitate the system to be more intelligent, learner-centered, and personalized (Kohrs, & Merialdo, 2001; Khribi, et al., 2009). In addition, the system implementation will involve more features of Web 2.0. Web 2.0 engages a group of users with similar interesting in exhibits and facilitates these users to exchange their opinion. This would enable high user cognition to the exhibits (Brown, 2006) and opens a window for collaborative learning (Terntin, 2008; Rubio et al., 2009).

Acknowledgements

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A Multivariate Model of Factors Influencing Technology Use by Preservice Teachers during Practice Teaching

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ABSTRACT
Teacher education courses training and participating in school-based field practice are important processes for equipping preservice teachers with technology integration ability. However, preservice teachers still lack the ability and knowledge needed to teach successfully with technology. This paper investigates the significance of, and relationships between, process factors and their direct and indirect effects on technology integration and further tests a multivariate hypothesized model. Structural equation modeling was applied to model the relationships in a set of latent variables. A questionnaire was developed and validated to identify factors influencing technology integration by 401 preservice teachers in the practicum context. The analytical results reveal that teacher education courses fail to facilitate preservice teachers’ technology integration in a practicum context. However, preservice teachers’ experiences with mentors can help preservice teachers use technology while practicing teaching. Additionally, the resulting model had an adequate fit to observed relationships among factors influencing teacher technology use during practice teaching. The implication for teacher education is that technology should be integrated into core method courses, not limited to isolated courses. The research model can serve as a base model for future studies.

Keyword
Technology integration, Preservice teachers, Teacher education

Introduction
Technology use can improve student learning. Relevant studies concluded that using technology in educational settings benefits students (Gülbahar, 2007; Kim & Hannafin, 2011). Many governments worldwide have invested money in constructing environments that increase technology access in elementary and secondary school classrooms. Taiwan’s government has also funded projects that promote innovative teaching with technology. However, many studies that include Taiwanese have indicated that technology integration in the classroom by teachers is insufficient (Chen, 2008; Gorder, 2008; Hermans, Tondeur, van Braak, & Valcke, 2008). This lack of technology integration is reflected in preservice teacher education. The importance of developing the ability of preservice teachers to integrate technology has been widely recognized.

The National Council for Accreditation of Teacher Education (NCATE) developed the National Education Technology Standards for Teachers (2008) and Interstate New Teacher Assessment and Support Consortium standards (2003) as teacher accreditation requirements. These standards require that teachers use technology in their classrooms, and design learning environments and experiences that support teaching, learning, and curricula. These standards have also led teacher education institutes to acknowledge shortcomings in teacher preparation for using technology as an effective instructional tool.

Teacher education institutions are natural places for training teachers in how to integrate technology into daily classroom learning. Although numerous institutes have allocated considerable effort to develop thoughtful technology-based programs, only a few studies have evaluated these programs (Kay, 2006). Additionally, empirical evidence indicates that teacher education programs have not taught new teachers how to use technology effectively (Maddux, & Cummings, 2004); that is, preservice teachers still lack the ability and knowledge needed to teach successfully with technology (Angeli, & Valanides, 2008).

Although teacher education courses related to technology integration were inadequate, a learning opportunity arising from school-based field practice for preservice teachers has been acknowledged. To attain sufficient experience in technology integration, preservice teachers can interact with mentors during a practicum. Nilsson and Driel (2010) indicated that teacher knowledge can be enhanced and developed via the interaction between preservice teachers and mentors during a practicum.
Moreover, teacher pedagogical beliefs are important when exploring technology integration. These beliefs play a critical role in successful technology integration (Ertmer, 2005; Hermans, et al., 2008; Tondeur, van Keer, van Braak, & Valcke, 2008). Beliefs about teaching can be called “preferred ways of teaching” (Teo, Chai, Hung, & Lee, 2008). Technology integration is the implementation of technology during teaching. Therefore, beliefs of preservice teachers about technology integration potentially influence their teaching methods when using technology.

Actual technology use by preservice teachers during a practicum may be related to their training, school-based field experiences with mentors (EWMs), and beliefs about technology integration because preparation courses and participating in field practice foster professional abilities and shape pedagogical beliefs of preservice teachers. Many studies have explored teacher education programs (e.g., Sandholz & Reilly, 2004), preservice teacher beliefs (e.g., Ertmer, 2005), technology access (e.g., Dexter & Reidel, 2003), and self-efficacy (e.g., Chen, 2010), while few studies documented the combined effects of two major teacher education processes, teacher education courses and school-based field practice courses, which further shape teacher beliefs about integrating technology and teaching, even though these processes are necessary to equip preservice teachers with the required professional skills. This study investigates the significance of, and relationships between, process factors and their direct and indirect effects on technology integration. This study also tests a multivariate hypothesized model. Study results reveal correlation effects of process factors influencing technology use by preservice teachers during practice teaching.

**Literature review**

Many factors consisting of internal and external aspects influence technology integration by preservice teachers during practice teaching. Determining the relationships between these factors as direct and indirect effects on technology integration contributes to the development of a multivariate hypothesized model.

**Teacher education courses, beliefs, and technology integration**

Many researchers have indicated that most teacher education courses worldwide did not provide meaningful contexts for applying technology to improve teaching and learning. Additionally, these courses did not prepare preservice teachers to use technology in instructional settings, even though over half of these countries acknowledged that technology has become compulsory when training teachers as primary or secondary school educators (Balcon, 2003; Moursund & Bielefeldt, 1999). A few countries have addressed the pedagogical application of technology for teaching and learning during teacher training (Usun, 2009).

The teaching philosophy of administrators at teacher education institutes regarding technology integration has been identified as an obstacle preventing successful implementation of technology in classrooms (Dexter et al., 2003; Doering, Hughes, & Huffman, 2003). Leu and Kinzer (2000) argued that many teacher education programs did not prepare teachers for integrating technology into instruction because the teacher education courses were isolated courses worth only two or three credits. Isolated courses have difficulty generating students as masters of the technical skills needed for meaningful application of these skills for student learning. According to Singer and Maher (2007), preservice teachers felt that many experiences and resources in courses in teacher education programs were not helpful for technology integration. Brown and Warschauer (2006) advocated that technology should be integrated into method courses to give preservice teachers effective strategies for integrating technology into classroom instruction, rather than focusing predominantly on technical skills or knowledge.

However, some studies noted that information literacy courses in teacher education programs altered the information-seeking behaviors of these students (Branch, 2003), and increased their confidence in using technology, while course training did not generate actual teaching practice (Branch, 2003; Swain, 2006).

Although these studies identified insufficient outcomes of teacher education courses, these courses remain critical for equipping preservice teachers with the ability to use technology in their teaching careers (Chen & Ferneding, 2003; Franklin, 2007). Empirical evidence indicates that preservice teachers have been equipped with technology skills, not the ability to integrate technology (Maddux & Cummings, 2004; Moursund & Bielefeldt, 1999; Selinger, 2001). Moreover, teacher pedagogical beliefs likely influence teaching practices (Kane, Sandretto, & Heath, 2002; Pajares,
Many researchers have demonstrated that teacher pedagogical beliefs are critical in successful technology integration (Ertmer 1999, 2005; Hermans et al., 2008; Tondeur et al., 2008) and are a significant determinant in interpreting why teachers utilized computers in classrooms (Hermans et al., 2008). The beliefs of preservice teachers are also markedly influenced their subsequent instructional decisions and classroom practice (Pajares, 1992; Richardson, 2003). Consequently, teaching preservice teachers how to critically analyze their beliefs about technology use in classrooms influences their technology integration practices (Valcke, Sang, Rots & Hermans, 2010); that is, the pedagogical beliefs of preservice teacher directly predict their technology integration during practice teaching (Sang, Valcke, van Braak, & Tondeur, 2010).

However, some researchers demonstrated the teacher beliefs about the value of educational technology were not good predictors of their instructional practices (Ertmer, Gopalakrishnan, & Ross, 2001; Judson, 2006). Ertmer (2005) also noted that teacher beliefs did not always inform practice.

Lambert, Gong and Cuper (2008) showed that preservice teachers had positive pedagogical beliefs about the importance of computers in education after taking educational technology courses, and indicated that educational technology courses enhance the beliefs of preservice teachers about the benefits of technology use and prepared them to use technology effectively. According to Pajares (1992), teacher beliefs are established by experiences and influenced by professional contexts. When students enter teacher education programs, their beliefs have already been shaped by their personal experiences as students (Keys, 2007; Pajares, 1992; Raths, 2001). That is, preservice teachers’ beliefs may be shaped by teacher education programs and are relatively stable and resistant to change.

Based on this assertion, literature reveals that teacher education courses may shape pedagogical beliefs of preservice teachers and enhance their technology skills, rather than the ability to integrate technology while teaching. As a result, teacher education courses shape preservice teacher beliefs and, further, beliefs are predictive of technology integration and worthy of exploration.

**Experiences with mentors, beliefs, and technology integration practices**

School-based field practice courses in teacher education programs provide preservice teachers with opportunities to observe and interact with mentors, thereby acquiring practical teaching experience. Typically, an experienced teacher writes a mentoring proposal for preservice teacher development to help preservice teachers learn important teaching skills such as designing effective learning activities and assessing student prior knowledge of certain topics (Carroll, 2005). This school-based internship offers both opportunities and challenges for mentors and preservice teachers.

In Taiwan teacher education system, each teacher education student has to participate in school-based field practice after completing all university courses and is assigned at least one mentor for practice teaching. Preservice teachers cannot implement technology integration during practice without permission from their mentors because the responsibility to educate students resides with mentors, not the preservice teachers. The perspectives of, and guidance from, mentors markedly influence technology integration by preservice teachers during practice teaching.

Grove, Strudler, and Odell (2004) applied qualitative methods to collect various perspectives on technology integration during mentoring and student teaching experiences. Grove et al. determined that preservice teachers were aware of mentors’ models and student-centered learning activities with technology. Additionally, mentors provided opportunities for preservice teachers to examine their teaching practices and discuss technology integration strategies. Judge and O’Bannon (2007), who examined preservice teachers and mentors participating in a technology teaching model, indicated that preservice teachers incorporated technology into their teaching activities during field experiences while guided by their mentors. Furthermore, in addition to determining that field experiences were effective for preservice teachers in developing the ability to integrate technology into instruction, Judge et al. demonstrated that mentor teachers should use technology and be able to model, mentor, and guide preservice teachers as they learn to use technology to enhance curricula and improve student learning. Haydn and Barton (2007) explored the beliefs of preservice teachers and their mentors and determined that preservice teachers, discussing technology issues with their mentors and either observing or utilizing something with technology positively impacted instructional quality and subject learning. Based on these studies, participating in school-based field experiences with mentors positively affects technology integration during practice teaching for preservice teachers.
However, Singer and Maher (2007) explored the interventions of two pairs of preservice teachers and their mentors in a technology-rich curriculum and determined that the beliefs of preservice teachers about student learning with technology were far from those of their mentors. That is, pedagogical beliefs of preservice teachers may be influenced by other aspects, such as teacher education courses. Moreover, Sahin (2008) demonstrated that many preservice teachers were not exposed to extensive use of technology during their internships because not all mentors used technology while teaching; this may have affected preservice teacher beliefs about technology use. In contrast to previous studies of effective mentoring, the study by Sahin indicated that mentors do not provide preservice teachers with the skills needed for technology integration. Grove et al. (2004) argued that mentors must develop knowledge about how to teach innovatively with technology, have access to technology to practice and develop lessons, and learn how to mentor preservice teachers in teaching in ways that are consistent with existing standards.

Moreover, in terms of preservice teacher beliefs, beliefs of teacher educators at universities can affect preservice teacher beliefs (Bai & Ertmer, 2008), and mentor beliefs influence the beliefs of preservice teachers. Freese (1999) designed a framework that guides preservice teachers in systematically analyzing their lesson plans before, during, and after teaching. Freese suggested that modeling, interaction, and lived experiences while co-constructing and co-reflecting on teaching with mentors was valuable and impacted the beliefs and practices of preservice teachers. Kajder (2005) demonstrated that mentor pedagogical beliefs, as perceived by preservice teachers, markedly influenced preservice teacher beliefs about technology use during practice teaching. Therefore, school-based field experiences with mentors directly or indirectly through teaching beliefs influence preservice teacher technology integration.

**Brief summary and hypothesized influence model**

Several studies analyzed teacher education courses that affect technology integration by preservice teachers (Brown & Warschauer, 2006; Leu & Kinzer, 2000; Singer & Maher, 2007). Notably, school-based field experiences with mentors influence preservice teacher technology use during practice teaching (Grove et al., 2004; Haydn & Barton, 2007; Judge & O’Bannon, 2007; Singer & Maher, 2007). Additionally, some studies identified the shape (Keys, 2007; Lambert et al., 2008) and the effects (Sang et al., 2010; Valcke et al., 2010) of preservice teacher beliefs about the integration of technology and instruction. However, exploring each factor influencing technology integration individually is difficult, especially when trying to interpret the perspectives of preservice teachers on technology use when teaching students in a practicum context. Moreover, teacher education courses and school-based field practice are two important processes in which diversity trainings provide preservice teachers with professional skills. Consequently, when exploring preservice teacher technology use during practice teaching, one must examine teacher education courses in colleges and field experiences with mentors in the practicum context, while also examining teacher beliefs about technology integration. By identifying direct and indirect relationships among factors, this study develops a multivariate hypothesized model (Figure 1).

![Figure 1. A multivariate hypothesized model](image)

**Research Methodology**

**Research design**

This study evaluates a multivariate hypothesized model that predicts the significance of, and relationships among,
process factors and their direct and mediated effects on technology integration for preservice teachers during practice teaching in school-based field practicum in Taiwan. Structural equation modeling (SEM) was applied to model the relationships in a set of the following four latent variables: perceived usefulness of teacher education courses; school-based field EWMs; beliefs of preservice teachers about technology integration; and, technology integration during practice teaching. A survey was conducted to collect data. Analyses of the measurement model and path model were included in SEM. The measurement model is a conventional confirmatory factor model, representing a set of observed variables that are multiple indicators of a set of latent variables, which was used to assess data validity. During path analysis, the effect of one latent variable on another is decomposed into direct, mediated, and total effects. A direct effect is the influence of one variable on another that is not mediated by another variable, whereas a mediated effect is the influence of one variable on another that is mediated by at least one other variable. The sum of direct and mediated effects is the total effect (Bollen, 1989).

Research participants

The initial sample comprised 202 preservice secondary school teachers who participated in school-based field practice between August 2010 and January 2011. These teachers were randomly chosen from a university of teacher education in Taiwan. Each sampled preservice teacher and the other preservice teachers within the same secondary school, who were from other universities of teacher education, were invited to fill out the study questionnaire during December 2010 to January 2011. In total, 466 questionnaires were returned, of which 401 questionnaires were valid. The sample consisted of 133 male (33.2%) and 268 female (66.8%) graduated from 18 universities, who majored in mathematics (10.2%), literacy and language arts (24.0%), sciences (9.5%), social studies (8.7%), arts and physical education (11.7%), vocational professions (11.5%), integrative activities (12.2%), and special education (12.2%).

Before participating in school-based field practice courses, preservice teachers in Taiwan must major in a teaching field, complete at least 26 credits in education courses, and be enrolled in at least three courses related to instructional methods and technology, including Instructional Principles, Classroom Management, Theory and Practice of Counseling, Instructional Multimedia and Utilization, Curriculum Development and Design, and Educational Testing and Assessment. Additionally, the Subject/Field-Specific Teaching Method course is a required course.

Instruments

A questionnaire was developed to identify factors influencing technology integration by preservice teachers in the practicum context. Four sections associated with four variables were included in the survey. Individual items were developed based on literature (Table 1).

The first section, perceived course usefulness (PCU) has 2 items. Perceived usefulness is defined as the degree to which a person believes that using a particular system will enhance his/her job performance (Davis, 1989). The PCU section, addressing the perceived usefulness of technology integration training in teacher education courses, measures the knowledge and ability of preservice teachers to enhance instruction with technology. The second section, beliefs about teaching (BAT) has 4 items for willingness, acceptance, supposition, and confidence in technology integration, based on the belief definition by Teo, Lee, Chai and Wong (2009), who defined belief as an individual’s estimated probability that performing a given behavior will result in a consequence. The third section, preservice teachers’ experiences with mentors (EWMs) has 3 items—observing mentors (Haydn & Barton, 2007), receiving guidance (Judge & O’Bannon, 2007), and perceived teaching characteristics of mentors (Grove et al., 2004). The final section, technology integration implementation (TII), has 4 items for four general teaching processes—lesson design, material design, teaching activities, and assessments using technology.

Responses to each item were on a four-point Likert scale with 1 for “strongly disagree” to 4 for “strongly agree.” All items were repeatedly revised by five professors with relevant expertise. Cronbach’s alpha was initially calculated to assess the internal consistency and reliability of the four variables. The alpha value for PCU was 0.76, that for BAT was 0.93, that for EWMs was 0.75, that for TII was 0.94, and that for the total questionnaire was 0.86.
Data analysis

After collecting data, evaluating homogeneity in teaching fields, and confirming internal consistency reliabilities, multivariate normality, validity through factor loadings for the measurement model, the entire model, and model fit were analyzed.

A one-way analysis of variance (ANOVA) was applied to determine whether teaching fields which preservice teachers majored in differ in four variables. The analytic results reveal insignificant differences in teaching fields (PCU, $F=2.795$, $p>.01$, BAT, $F=.747$, $p>.01$, EWMs, $F=2.681$, $p>.01$, TII, $F=.685$, $p>.01$), which eliminates the potential effect of the teaching fields on four latent variables.

Assessment of multivariate normality

Structural equation modeling programs utilize maximum likelihood (ML) estimation, which is robust for normality violations and provides remedies for non-normal variables. Parameters were examined to evaluate data normality. According to Bollen and Long (1993), for univariate normality, when both skewness coefficients and that of kurtosis have absolute values < 2.0, normality is reached. This study generated coefficients of -0.469 – -0.078 for skewness and -0.817 – 1.435 for kurtosis (Table 1). That is, data did not violate the univariate normality assumption for each observed variable.

According to Bollen (1989), when Mardia’s coefficient is less than $p (p + 2)$, where $p$ is the number of observed variables, multivariate normality exists. In this study, Mardia’s coefficient was 101.844, $p= 13$, 101.844 < 13 (13 + 2) = 165; thus, multivariate normality existed.

| Table 1. Descriptive Statistics and Assessment of Normality |
|---------------------------------|----------|-------|-------|
| Observed variables               | Mean     | SD.   | skew  | kurtosis |
| Teacher education courses equipped me with technology integration knowledge. (PCU1) | 2.95     | 0.90  | -.201 | -.817    |
| Teacher education courses enhanced my technology integration effectiveness. (PCU2) | 2.76     | 0.91  | -.435 | -.693    |
| I am willing to use technology during my teaching career. (BAT1) | 3.28     | 0.59  | -.469 | .935     |
| I accept the fact that technology helps students learn. (BAT2) | 3.33     | 0.55  | -.210 | .370     |
| Every teacher should develop technology integration ability. (BAT3) | 3.30     | 0.56  | -.219 | .389     |
| I have strong confidence in my ability to implement technology integration. (BAT4) | 3.31     | 0.56  | -.248 | .346     |
| Observing my mentor teach was helpful for my technology integration. (EWMs1) | 3.07     | 0.57  | -.317 | 1.435    |
| Receiving mentor guidance was helpful for my technology integration. (EWMs2) | 3.00     | 0.60  | -.207 | .456     |
| Perceived mentor characteristics facilitate my technology integration. (EWMs3) | 2.88     | 0.66  | -.226 | .096     |
| I have designed at least a lesson that uses technology. (TII1) | 3.32     | 0.55  | -.078 | .580     |
| I have designed digital material for lesson preparation. (TII2) | 3.27     | 0.56  | -.175 | .526     |
| I have employed teaching activities that utilize technology. (TII3) | 3.19     | 0.57  | -.190 | .461     |
| I have used technology to assess student performance. (TII4) | 3.30     | 0.53  | -.179 | .413     |
| Multivariate (Mardia’s coefficient) | 101.844 |

Validity

To assess validity, standardized regression loading of each observed indicator, and average variance extracted (AVE) compared with correlation coefficients for latent variables were calculated. Standardized regression loading was evaluated for construct validity, and AVE was used for discriminant validity.

Table 2 shows the standardized factor loading of each observed variable. The factor loadings were 0.646 – 0.927 (t-values, 2.17 – 12.62, $p<.05$), exceeding the recommended minimum of 0.50 (Hair, Anderson, Tatham, & Black, 1998). According to Bagozzi and Yi (1998), when construct validity of latent variables exceeds 0.60, measurement instruments have construct validity. The construct validity of each latent variable was 0.750 – 0.898; that is, > 0.60 (Table 2).
Additionally, AVE of each latent factor exceeded 0.5, and all square roots of AVE for the four factors exceeded the correlation coefficients among factors, demonstrating good discriminant validity (Anderson, & Gerbing, 1988). The AVE range was 0.501 – 0.714 (> 0.5), and the square root of AVE for each factor was 0.708 – 0.845, greater than the coefficients for correlations among factors (Table 2). Therefore, measurement instruments had discriminant validity.

**Evaluation of the entire model**

Notably, SEM can determine the significance of variance in the entire model. The estimated result had a high significance level ($\chi^2=112.345$, $df=60$, $p=.000<.001$). The appropriateness of model data was significant.

### Table 2. Construct and Discriminant Validity

<table>
<thead>
<tr>
<th>Latent variables</th>
<th>Observed variables</th>
<th>Loading</th>
<th>Construct</th>
<th>AVE</th>
<th>$\sqrt{AVE}$</th>
<th>correlation coefficients among the factors</th>
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<td>PCU1</td>
<td>.790*</td>
<td>.755</td>
<td>.607</td>
<td>.779</td>
<td>.192* for PCU - BAT</td>
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<tr>
<td></td>
<td>PCU2</td>
<td>.768*</td>
<td></td>
<td></td>
<td></td>
<td>.183* for PCU - EWMs</td>
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<tr>
<td></td>
<td>BAT1</td>
<td>.837*</td>
<td></td>
<td></td>
<td></td>
<td>.209* for PCU - TII</td>
</tr>
<tr>
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<td>.924*</td>
<td>.898</td>
<td>.714</td>
<td>.845</td>
<td>.300* for BAT - EWMs</td>
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<tr>
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<td></td>
<td></td>
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<td>.373* for BAT - TII</td>
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<td>BAT4</td>
<td>.796*</td>
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<td>EWMs</td>
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<td>.885</td>
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<tr>
<td>TII</td>
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<td>.911*</td>
<td></td>
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<td></td>
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</tr>
<tr>
<td></td>
<td>TII3</td>
<td>.814*</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>TII4</td>
<td>.923*</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

*p<.05, **p<.01

**Model fit analysis**

According to Kline (2005), the suggested $\chi^2/df$ value is < 3 for large samples. For this model, $\chi^2/df = 112.345 / 60 = 1.872$ (< 3), the value was adequate. Additionally, according to suggested guidelines from Bollen (1989), Kline (2005), and Pedhazur (1997), all other values related to model fit indices were favorable; that is, the research model had a good fit. Table 3 lists model fit results.

### Table 3. Results of model fit indices for the model

<table>
<thead>
<tr>
<th>Model fit indices</th>
<th>Values</th>
<th>Suggested guidelines</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\chi^2/df$</td>
<td>1.872</td>
<td>&lt; 3</td>
</tr>
<tr>
<td>CFI</td>
<td>.985</td>
<td>$\geq .9$</td>
</tr>
<tr>
<td>GFI</td>
<td>.960</td>
<td>$\geq .9$</td>
</tr>
<tr>
<td>AGFI</td>
<td>.939</td>
<td>$\geq .9$</td>
</tr>
<tr>
<td>NFI</td>
<td>.968</td>
<td>$\geq .9$</td>
</tr>
<tr>
<td>IFI</td>
<td>.985</td>
<td>$\geq .9$</td>
</tr>
<tr>
<td>RMSE</td>
<td>.025</td>
<td>$&lt; .05$</td>
</tr>
<tr>
<td>RMR</td>
<td>.047</td>
<td>$&lt; .05$</td>
</tr>
</tbody>
</table>

**Path analysis**

Figure 2 shows the path coefficients among each latent variable. Two of the five path estimates were insignificant, and the rest reached significant. All path coefficients were positive. According to Cohen’s recommendation,
interpretations of effect size of correlations are based on standardized path coefficients with absolute values—small effect (≤ 0.1), medium effect (> 0.1, < 0.5), and large effect (≥ 0.5) (Kline, 2005). The total effects, direct effects, and indirect effects among the five latent variables were calculated.

The standardized total effect of BAT on TII was 0.52. Even though the effect of PCU on TII was insignificant, the effect of PCU on BAT was 0.11, and the total effect of PCU on TII was 0.06, a very small effect. That is, when preservice teachers’ PCU increase 1SD, TII increases weakly by 0.06SD. The standardized effect of EWMs on TII was 0.27, the effect of EWMs on BAT was 0.32, and the total effect of PCU on TII was 0.44 (0.27 + 0.32 × 0.52), a moderate effect. That is, when preservice teachers’ EWMs increases 1SD, TII increased by 0.44SD.

In terms of preservice teacher PCU, the total effect on TII was very small, while the effect of EWMs on TII was moderate.

![Figure 2. Path coefficients of the research model](image)

**Conclusions and discussion**

Analytical results reveal that perceived usefulness of teacher education courses, in terms of total effects, has a small influence on technology use. That is, teacher education courses do not generate sufficient technology integration knowledge, thereby failing to facilitate preservice teachers’ technology use when teaching students in a practicum context.

Moreover, the preservice teacher EWMs in the practicum context has a moderate effect on TII and BAT. Thus, this study demonstrates that participating in school-based field EWMs help preservice teachers use technology while practicing teaching.

Additionally, the resulting model had an adequate fit to observed relationships among factors influencing teacher technology use during practice teaching.

**Effects of teacher education courses**

Teacher education courses were perceived by preservice teachers as ineffective in providing sufficient technology integration experiences during practice teaching. These analytical results are corroborated by research findings in literature, indicating that course training was useless in terms of technology integration by preservice teachers (Singer & Maher, 2007). This analytical result which is also supported by previous research (Branch, 2003; Swain, 2006) does not predict actual technology use during practice teaching.

However, teacher education courses have many benefits. Similar to findings in previous research (Keys, 2007; Lambert et al., 2008; Pajares, 1992; Raths, 2001), analytical results in this study confirm that teacher courses have positive effects on the pedagogical beliefs of preservice teachers; that is, pedagogical beliefs can be shaped by experiences as teacher education students.
Furthermore, the pedagogical beliefs of preservice teachers, similar to findings in previous research (Pajares, 1992; Richardson, 2003), markedly influence their subsequent instructional decisions about technology integration and classroom practice based on the analytical finding that pedagogical beliefs have a significant effect on technology use during practice teaching.

The total effect of PCU on TII was small. Consistent with previous literature, teacher education courses did not provide sufficient instruction in how to combine technology and instruction (Leu & Kinzer, 2000). One possible explanation is that isolated training course existed. Technology integration in a classroom must be combined with subject content and instructional strategies. Thus, isolated courses, such as Instructional Principles and Instructional Multimedia and Utilization, cannot provide complete concepts and actual practice in integrating technology and instruction. Although the Subject/Field-Specific Teaching Method course combines subject content and instructional strategies, whether content about integrating technology into instruction is taught depends on educator beliefs about technology use in classrooms. Consequently, although teacher education courses can equip preservice teachers with technology skills or promote instructional strategies, those courses remain insufficient for teaching practice using technology according to evaluation results for the total effect of PCU on TII.

Effects of experiences with mentors

Another study finding is clearly consistent with those in previous research (Grove et al., 2004; Judge & O’Bannon, 2007; Haydn et al., 2007), indicating that preservice teacher EWMs positively affected TII during practice teaching. Additionally, analytical results also confirm that preservice teacher EWMs facilitate technology integration (Freese, 1999; Valcke et al., 2010).

Participating in school-based field practice is important in teacher education programs in Taiwan. For practice teaching, preservice teachers are assigned at least one mentor, who guides preservice teachers in designing appropriate learning activities and assessing student prior knowledge of, and experiences with, a subject. Thus, EWMs, consisting of observing mentors teaching, and receiving guidance from mentors, perceived mentor characteristics, positively affected technology use by preservice teachers during practice teaching.

Another analytical result indicates that EWMs positively affect the pedagogical beliefs of preservice teachers. Similar to findings in previous research (Freese, 1999; Kajder, 2005), interaction and lived experiences in co-constructing and co-reflecting on teaching practices with mentors influence the pedagogical beliefs of preservice teachers. According to Raths (2001), teacher pedagogical beliefs can be shaped by experience. Generally, preservice teachers in school-based field practice spend most of their time interacting with mentors and being guided by mentors. The beliefs of mentors about educating students and teaching methods may be adopted by preservice teachers who have no practical experience or are aware of the uselessness of teacher education courses about technology use during practice teaching. When preservice teachers have successful experiences or make few teaching mistakes when using a mentor’s methods, they would likely adopt the mentor’s model and structure their educational perspectives and teaching strategies such that they are similar to those of their mentor. This is why the effect of preservice teacher EWMs rather than PCU on BAT was significant.

Moreover, the pedagogical beliefs of preservice teachers greatly influence their subsequent instructional decisions on technology integration and classroom practice. These analytical results confirm that school-based field EWMs are critical, and are mediated through pedagogical beliefs, influencing preservice teachers’ TII.

In Taiwan, similar to many countries, teacher education courses and school-based field practice are two important processes to equip preservice teachers with professional skills. This study documented the relationship effects of combining teacher education courses usefulness and school-based field EWMs, further shaping pedagogical beliefs about technology integration for preservice teachers during practice teaching. A noteworthy finding is that teacher education courses had a much weaker effect on technology use than EWMs in school-based field practice. As mentioned previously, technology use during teaching benefits students regardless of which subject. Preservice teachers should be equipped with the ability to technology integration to enhance their subsequent students’ learning. However, the study concludes teacher education courses fail to facilitate preservice teachers’ technology use when teaching students in a practicum context. The lack of the ability to technology integration for preservice teachers may inhibit innovative teaching and affect students’ learning. While teacher education institutes at universities are natural
places to develop teaching skills, this study finding can be contrasted with recommendations by Brown and Warschauer (2006), namely, single courses should be revised to provide preservice teachers with effective strategies for integrating technology into classroom teaching, rather than focusing on technical skills or knowledge.

As literature mentioned earlier, preservice teachers felt that teacher education courses were not helpful for technology integration (e.g., Singer & Maher, 2007). Additionally, preservice teachers can develop the ability to integrate technology into instruction while guided by their mentors (e.g., Judge & O’Bannon, 2007). This study synthesizes the above two perspectives, and adds teacher belief as a mediate variable, to develop a new model for investigating the effective factor in technology integration for pre-service teachers and to indicate effectiveness of EWMs.

Implications and limitations

Professional courses at teacher education institutes must be re-examined to promote preservice teacher use of technology while teaching. In terms of Taiwan, current teacher education system has not contained the courses that combine technology, pedagogy, and subject content yet. Several countries are also similar to Taiwan. I recommend that technology should be integrated into core method courses, not limited to isolated courses. Further, this study identifies the factors influencing technology use by preservice teachers during teaching practice, particularly for the two important processes of teacher education, teacher education course training and school-based field experiences. The research model can serve as a base model for future studies.

The study has one significant limitation. Course information in this study is from Taiwan’s Ministry of Education. However, Taiwan has 40 universities with teacher education departments that train secondary school teachers (Center for Educational Research and Evaluation, Taiwan, 2010). The sample of this study graduated from 18 universities. Although all preservice teachers must complete at least 26 credits in education courses before participating in school-based field practice, some universities do not provide a sufficient number of elective courses for students, as qualified lecturers are lacking. Thus, a bias may exist due to differences in students enrolling in training courses.

References


Designing a Personalized Guide Recommendation System to Mitigate Information Overload in Museum Learning

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ABSTRACT

Museum learning has received a lot of attention in recent years. Museum learning refers to people’s use of museums to acquire knowledge. However, a problem with information overload has caused in engaging in such learning. Information overload signifies that users encounter a mass of information and need to determine whether certain information needs to be retained. In this paper, we proposed a personalized guide recommendation (PGR) system to mitigate this problem. The system used association rule mining to discover guide recommendation rules both from collective visiting behavior and individual visiting behavior, and then the rules were personalized. Using this system, visitors can obtain a PGR and avoid exposure to excessive exhibit information. To investigate user satisfaction with the PGR system, a user satisfaction questionnaire was developed to analyze the user satisfaction in a sample consisting of individuals of different genders and ages. The results showed that both men and women consistently accepted the PGR system and revealed that there were significant differences with regard to attitudes toward the system’s service quality among different user ages. It was inferred that one possible reason for this was an effect related to users’ prior experience with computers. A summary of the findings suggested that the PGR system generally obtained positive feedback.

Keywords

Museum learning, Information overload, Personalized guide recommendation, Association rule mining

Introduction

In recent years, it has been shown that museums are one of the most important institutions serving as sources for informal learning (Sung, Chang, Hou, & Chen, 2010; Sung, Chang, Lee, & Yu, 2008; Tan, Liu, & Chang, 2007; Vavoula, Sharples, Rudman, Meek, & Lonsdale, 2009). Over time, museums have gradually developed into public learning centers, and they have been seen as serving a role in public education (Semper, 1990). This implies that museums have been viewed as one type of informal educational context and as an important asset by which to acquire knowledge. Consequently, museums play a significant role in providing people with in depth knowledge beyond formal educational contexts (Ramey-Gassert, Walberg III, & Walberg, 1994; Semper, 1990).

Although museums are accepted as a means to pursue knowledge, the problem of information overload (IO) still remains in existing museum contexts (Bitgood, 2009). IO implies that users encounter a mass of information and need to make a decision as to whether to retain information about a certain topic (Toffler, 1970). In museums, visitors often have to confront a vast number of exhibits and, due to time pressure, must make a decision about whether to view more details about a particular exhibit or to move on (Bitgood, 2009). However, such a situation may lead to a generation of IO because the large number of exhibits leads to confusion. More specifically, visitors may have an inability to process input because too many exhibits are presented at once or because the information is presented too quickly over time (Bitgood, 2009). Consequently, visitors may acquire only a superficial understanding through a quick and casual viewing of any given exhibit.

In this paper, a personalized guide recommendation (PGR) system is proposed to mitigate IO in museum contexts. Previous studies have indicated that recommendation systems can help reduce IO (Itmazi & Megias, 2008; Lee & Kwon, 2008; Yang & Chen, 2010). A recommendation system refers to a system that actively provides relevant information to users according to their interests so that they are no longer required to handle too much information. This means that the recommendation system can be used to ease visitor IO. In order to develop an appropriate recommendation system for museum contexts, collective and individual visiting behavior was analyzed in order to
recommend personalized guides for visitors. More specifically, a recommendation technique, association rule mining (ARM), was used to discover the PGR rules existing among collective visiting behaviors (Agarwal, Imielinski, & Swami, 1993; Sun, Kong, & Chen, 2005), and then the individual visiting behavior was used to improve the PGR rules in order to provide visitors with a PGR. In this innovative approach, each visitor is able to obtain a PGR service and relieve the distress associated with IO. Furthermore, the PGR system is different from virtual museum information system since visitors can take a mobile device with the PGR system out into authentic museum contexts.

For the purposes of this paper, an experiment was conducted to evaluate user satisfaction with a PGR system in museum contexts. Specifically, we implemented a PGR system and introduced the system into a university museum. Afterward, an evaluation model for user satisfaction with the PGR system was designed in order to evaluate the system. Subsequently, a questionnaire was developed to examine user satisfaction according to the evaluation model. Finally, a series of analyses were carried out to understand the user satisfaction with the PGR system.

Background and related studies

Relevant research on museum learning

Recently, research on museum learning has been quite diverse and has continued to grow. These studies have included enhancement of museum functions, investigations of virtual museums, and research on the connection between museum learning and formal learning. These studies are summarized as follows:

Research on enhancement of museum functions has focused on adopting various information technologies to enhance the effects of museums. Early on, researchers used interactive videodiscs to enhance the effect of exhibits (Hirumi, Savenye, & Allen, 1994). The results showed that an interactive videodisc can attract and hold visitor attention for longer periods of time than conventional exhibits lacking such amenities. Later, some studies utilized mobile technology such as electronic guidebooks to augment user experiences (Jeng, Wu, Huang, Tan, & Yang, 2010; Sung et al., 2010; Sung et al., 2008). These studies showed that electronic guidebooks resulted in patrons staying longer at exhibits as compared to the results for a paper-based guidebook. In addition to mobile technology, researchers have also expressed interest in ubiquitous technology (Huang & Wu, 2011; Huang, Chiu, Liu, & Chen, 2011; Wu, Sung, Huang, Yang, & Yang, 2011). Some researchers have used ubiquitous technology to detect the location of museum visitors and also to provide visitors with adaptive guides (Ghiani, Paternò, Santoro, Spano, 2009; Hall & Bannonw, 2006; Pianesi, Graziola, Zancanaro, Goren-Bar, 2009). Likewise, the results have indicated that adaptive guides can provide a richer overall experience and positively impact user engagement. Overall, the introduction of information technologies is helpful to promote the effects of museum visits.

Investigations into virtual museums have focused on applying Internet technology to develop virtual museums. Fomichova and Fomichov (2003) used Internet technology to create child-oriented art museum websites. In their study, the authors used websites to establish a bridge between the world of art and the inner world of a child in order to expand the child’s interest. With the development of virtual museums, Corredor (2006) explored the influence of prior knowledge on goal setting and content use in virtual museums. His study showed that both the domain knowledge and general knowledge of visitors influence both goal setting and the content use of museum visitors. Neill (2008) also reported a project regarding transnational cooperation (NEOTHEMI) among ten countries in Europe that developed a cultural heritage virtual museum. The report indicated that NEOTHEMI had helped students understand both their culture and other cultures better and also helped them to understand different perspectives on culture. Reynolds, Walker, and Speight (2010) utilized both Internet and mobile technologies to develop web-based museum trails for university-level design students. The trails offered students a range of ways to explore a museum environment and its collections. Their results showed that the trails promoted the students’ knowledge and interest in the museum used in the study. In sum, the development of virtual museums is also one of the important issues in museum learning.

The research on the connection between museum learning and formal learning has focused primarily on how to integrate museums into formal learning contexts. Morreale (2001) used hypermedia, database and network technologies to integrate museums into school activities. The results showed that both the creativity and mental outlook of pupils could be enhanced with these technologies. Cox-Petersen et al. (2003) explored the feasibility of using docent-led guided school tours at a museum of natural history. Their results indicated that the tours were
organized in a didactic way that conflicted with inquiry-based learning. The results also showed that student satisfaction with the tours was high but that the level of science learning was low. Vavoula et al. (2009) developed a Myartspace service on mobile phones for inquiry learning in museums. The Myartspace service allowed students to gather information and send the information to a website during museum field trips. In this manner, the students were able to view, share, and present the information regardless of whether they were in a classroom or at home. That is to say, a collaborative learning context was formed (Hwang, Huang, & Wu, 2011; Lin, Huang, Cheng, 2010). Their results showed that the Myartspace service was effective in assisting students in gathering information in museums and with providing resources for effective construction and reflection in the classroom.

Overall, museum learning has been extensively discussed. However, methods by which to assist visitors to ease IO have rarely been considered. At present, the issue of IO in museums has only been mentioned in a study of museum fatigue (Bitgood, 2009). To make up for this deficiency, the use of a PGR system to mitigate IO in museum contexts is being considered in this paper.

Information overload and its solutions

IO is one of important issues in learning and teaching scenarios (Chen, 2009; Paulo, 1999). IO means that there is too much information; it has negative connotations, and it is a widespread problem, especially in computer-mediated communication (CMC) contexts (Paulo, 1999). Moreover, IO is different from cognitive overload (CO). IO usually arises in an attention process in which users encounter disturbances due to excessive information, and it results in the loss of information (Chen, 2009). CO usually arises in knowledge construction processes in which users encounter difficulties in the storage and retrieval process, and it leads to failure in knowledge construction (Chen, 2009). Therefore, CO studies are focused on assisting learners in constructing knowledge (Cieriak, Scheiter, & Gerjets, 2009; Huang, Huang, Liu, & Tsai, 2011) while IO studies are focused on assisting learners in avoiding excessive information (Itmazi & Megias, 2008; Lee & Kwon, 2008; Yang & Chen, 2010). In this study, we focused on museum contexts that are IO contexts (Bitgood, 2009), so the term “IO” is studied in this paper rather than “CO.”

Recommendation systems are one of several useful techniques designed to cope with IO (Itmazi & Megias, 2008; Lee & Kwon, 2008; Yang & Chen, 2010) that have been used to assist users in identifying relevant information from a vast amount of information (Ghauth & Abdullah, 2010). In this manner, users are not exposed the risk of IO. Collaborative filtering (CF), content-based filtering (CBF), and hybrid filtering (HF) are the three most famous methods among the proposed recommendation systems (Ghauth & Abdullah, 2010; Wang, Tsai, Lee, & Chiu, 2007). CF refers to a system that use user attributes, such as browsing behavior, to predict items of interest for a user (Khribi, Jenni, & Nasraoui, 2009; Manouselis, Vuorikari, & Van Assche, 2010; Rodriguez, Sicilia, Sánchez-Alonso, Lezcano, García-Barriocanal, in press). That is to say, new items that have not been browsed by the user and new items that are of interest to similar users will be recommended to the user (Ghauth & Abdullah, 2010). CBF refers to a system that uses the attributes among items, such as categories of items, to predict items of interest for a user (Ghauth & Abdullah, 2010; Huang, Huang, Wang, & Hwang, 2009; Khribi et al., 2009; Yang & Chen, 2010; Yang, Huang, Tsai, Chung, & Wu, 2009). In other words, if the user was interested in an item in the past, it was assumed that he/she would probably be interested in other similar items in the future (Wang et al., 2007). HF refers to a system that combines CF and CBF to predict user likes or dislikes (Khribi et al., 2009; Wang et al., 2007). At present, HF is usually believed to be a better method for recommendation systems (Wang et al., 2007). In this study, the HF method is adopted in a PGR system that uses both collective and individual visiting behavior to recommend personalized guides for visitors, the details of which are described in the next section.

Personalized guide recommendation (PGR) system

The PGR system developed in this study was composed of a back-end subsystem and a front-end subsystem, as shown in Figure 1. The back-end subsystem was designed for staff to use, and it would be used on a desktop computer. The front-end subsystem was designed for visitors to use, and it would be used on netbook computer (Notebook, 2010). The functions of these subsystems are described in more detail below.
Figure 1. The framework of the PGR system

Back-end subsystem

A back-end subsystem provides staff with a management tool, which is comprised of an exhibit management function and a PGR rules generation function, as shown in Figure 2. The exhibit management function assists staff in managing exhibits, in which the members of a staff can use this function to add, modify, and delete exhibit information. Here, the exhibit information includes the name, category, description, image, location, and so on. The PGR rules generation function assists staff members in generating the PGR rules from the collective visiting behavior. When staff members want to generate the rules, this function will automatically connect to database to retrieve the visiting behavior of visitors and further generate the PGR rules. Afterward, the PGR rules can be used to provide PGR services for visitors. Moreover, since the visiting behavior of visitors is frequently added to database, an automatic update setting was embedded in this function for the purpose of assisting staff to automatically update PGR rules. In this manner, the PGR rules will become more significant over time because a large number of visiting records is useful in generating significant PGR rules.

Figure 2. The interface of the back-end subsystem
Front-end subsystem

A front-end subsystem provides visitors with a guide tool, which is comprised of an electronic guidebook function and a PGR service function, as shown in Figure 3 and Figure 4. The electronic guidebook function assists visitors in their museum visit, where the visitors can use this function to view more details about a particular exhibit as shown in Figure 4. In the meantime, the individual visiting behavior is also recorded into a visiting record table. When visitors finish their visiting activity, staff members will upload the table into the visiting record database of the back-end subsystem in order to update the PGR rules. The PGR service function is used to provide visitors with a personalized guide based on their visiting behavior and the PGR rules. By using this function, visitors have opportunities to avoid making a decision to view more details about a particular exhibit because this function will actively provide a suitable exhibit guide for them.

Figure 3. The interface of the front-end subsystem with an exhibit guide

Figure 4. The interface of the front-end subsystem with the PGR service
Here, an example is used to illustrate how to use the front-end subsystem to guide a visitor to visit exhibits. First of all, the visitor holds a mobile device with the front-end subsystem to visit the exhibits. During the period of visit, if the visitor is interested in an exhibit in one of the exhibit areas such as the dragon lock in the D area, he/she can click on the front-end subsystem’s button labeled “exhibit area D” to view the details of the dragon lock as shown in Figure 3. Afterward, the front-end subsystem will present the details of the dragon lock and recommend an exhibit to the visitor as shown in Figure 4. Consequently, the visitor can view more details about the dragon lock and have an opportunity to avoid the risk of IO through PGR service. With regard to the details of the PGR service, which are presented in the following subsection.

**PGR service**

A PGR service is an HF recommendation technique, which involves CF and CBF, as shown in Figure 5. The CF is performed in the back-end subsystem, and the CBF is executed in front-end subsystem. Specifically, the ARM technique and the Apriori algorithm (Agarwal et al., 1993; Sun et al., 2005) were first adopted to implement CF in order to generate the PGR rules. Afterward, the relationship both the category and location of exhibits and both the category of interest and location of visitors were formulized to implement CBF and then personalize the PGR rules. Their details are described as below.

![Figure 5. The PGR process](image)

The ARM technique is a powerful data mining method designed to search for interesting relationships between items by finding the items frequently appearing together in a transaction database (Agarwal et al., 1993; Sun et al., 2005). Hence, the ARM technique was used in this study to discover the relationships among the collective visiting behaviors of visitors by finding the exhibits that frequently appeared together in a visiting record database. In this manner, the visiting patterns among visitors could be found through ARM technique, and these patterns could be used as the PGR rules. In this study, a PGR rule is defined as an implication of the form \( X \Rightarrow Y \) where \( X, Y \) are sets of exhibits and \( X \cap Y = \emptyset \). \( X \) is called antecedent while \( Y \) is called consequent, the rule means \( X \) implies \( Y \). A PGR rule signifies that if a visitor has visited the exhibits in \( X \), he/she would like to visit the exhibits in \( Y \). Furthermore, support and confidence are used as thresholds to select the PGR rules. The support of a PGR rule \( X \Rightarrow Y \) is defined as the percentage of visiting records that contain \( X \cup Y \) to the total number of visiting records in the visiting record database. The confidence of a PGR rule \( X \Rightarrow Y \) is the percentage of visiting records that contains \( X \cup Y \) to the total number of visiting records that contain \( X \) in the visiting record database. In general, a strong rule has a large support and high confidence. However, in this work, visitors may have different ages and different background, and therefore may result in a diversity of visiting records. This signifies that the same visiting pattern among visitors may be relatively less, and thus both the support and the confidence of the PGR rules need to be set smaller and lower in order to discover more PGR rules, especially when the visiting record database is small. Once the visiting record database becomes large, both the support and the confidence of the PGR rules can be set larger and higher in order to discover more significant PGR rules. Subsequently, these rules would be improved to personalize in the front-end subsystem by using individual visiting behavior.

To personalize the PGR rules, the main idea of this work is to determine whether the category of the recommended exhibit is identical to the category of interest of the visitor and whether the recommended exhibit is around the visitor. To this end, both the category of interest and location of the visitor and both the category and location of recommended exhibit were used to evaluate the recommendation level between the visitor and the recommended exhibit. In order to understand the visitor’s interest in the category of exhibits, the category that occurred the most frequently among the visited exhibits was used as the category of interest of the visitor. Moreover, to identify the
possible location of the visitor, the location of the exhibit last visited by the visitor was also used to infer the location of the visitor. Accordingly, the recommendation level formula was defined as Equation (1). In this manner, the recommendation level between the visitor and the recommended exhibit could be computed through Equation (1). Consequently, the PGR system was able to use the recommendation level to provide a personalized guide.

\[
rl = \text{cat}(Vc, \text{REc}) + \text{loc}(Vl, \text{REL}),
\]

\[
\begin{align*}
\text{cat}(Vc, \text{REc}) &= 0 \text{ if } Vc \text{ and } \text{REc} \text{ is the same} \\
\text{cat}(Vc, \text{REc}) &= 1 \text{ otherwise}
\end{align*}
\]

\[
\text{loc}(Vl, \text{REL}) = \sqrt{(Vl_x - \text{REL}_x)^2 + (Vl_y - \text{REL}_y)^2} / \text{dist}_{max}
\]

where

- \(rl\) is the recommendation level between the visitor and the recommended exhibit;
- \(\text{cat}(Vc, \text{REc})\) is to determine whether both the category of interest of the visitor and the category of the recommended exhibit are the same;
- \(Vc\) is the category that occurs the most frequently in the visiting record table of the visitor, which is viewed as the category of interest of the visitor;
- \(\text{REc}\) is the category of the recommended exhibit;
- \(\text{loc}(Vl, \text{REL})\) is to compute the distance between the location of the visitor and the location of the recommended exhibit and convert the distance into a interval \([0,1]\);
- \((Vl_x, Vl_y)\) is the location of the exhibit last visited by the visitor, which is viewed as the location of the visitor;
- \((\text{REL}_x, \text{REL}_y)\) is the location of the recommended exhibit;
- \(\text{dist}_{max}\) is the maximum distance between all exhibits.

**Experimental design**

**Theoretical fundamental of evaluation: user satisfaction**

User satisfaction plays an important role in the successful development of e-learning systems (Bekele, 2010; Ho & Dzeng, 2010; Huang & Liu, 2009). An appropriate evaluation will motivate researchers to improve the development of e-learning systems. Hence, user satisfaction evaluations are used to recognize user needs and significant factors in order to improve systems and to obtain user acceptance (Bekele, 2010; Ho & Dzeng, 2010; Ong, Day, & Hsu, 2009). Such evaluations can provide suggestions regarding system design and can facilitate the improvement of systems. Furthermore, such evaluations can also be used to understand whether systems meet user requirements and demonstrate system value (Ong et al., 2009). Consequently, in this study, user satisfaction is adopted as a theoretical fundamental of evaluation by which to evaluate PGR system.

To investigate user satisfaction with the PGR system in museum contexts, a comprehensive model proposed by Ong et al. (2009) was modified in the experiment. Ong et al. (2009) proposed four constructs, which included perceived ease of use (PEU), perceived usefulness (PUF), perceived service quality (PSQ), and perceived information quality (PIQ) in order to evaluate user satisfaction. PEU refers to users’ belief that using a technology will be free of effort (Davis, 1989). PUF refers to users’ belief that using a technology will enhance his/her job performance (Davis, 1989). PSQ refers to users’ judgment on the overall excellence or superiority of a system (Ong et al., 2009). PIQ refers to users’ judgment on the content of a system (Ong et al., 2009). In addition to the four constructs, perceived information overload (PIO) was also considered in this model. PIO is defined as users’ judgment on whether they can engage in exhibit visitation. Due to the fact that IO is one of the factors influencing museum fatigue (Bitgood, 2009), PIO was added as one of the constructs for evaluating user satisfaction. Consequently, the five constructs formed an evaluation model as shown in Figure 6, which are used to develop a questionnaire for investigating user satisfaction with the PGR system.
Questionnaire

A structured questionnaire was developed based on a review of prior studies (Bitgood, 2009; Davis, 1989; Ong et al., 2009) as well as feedback from experts. The improved questionnaire was distributed to the visitors, who were required to complete the questionnaire by indicating their level of agreement with a five-point Likert scale, as shown in Table 1.

<table>
<thead>
<tr>
<th>Construct</th>
<th>Item</th>
</tr>
</thead>
<tbody>
<tr>
<td>PEU</td>
<td>(PEU1) I think that operating the system is easy.</td>
</tr>
<tr>
<td></td>
<td>(PEU2) I think that learning to use the system is easy.</td>
</tr>
<tr>
<td></td>
<td>(PEU3) I think that the functions of the system are easy to understand.</td>
</tr>
<tr>
<td>PUF</td>
<td>(PUF1) I think that using the system can result in knowledge of the exhibits.</td>
</tr>
<tr>
<td></td>
<td>(PUF2) I think that using the system can satisfy my curiosity about exhibits.</td>
</tr>
<tr>
<td></td>
<td>(PUF3) I think that using the system can promote convenience in visiting the museum.</td>
</tr>
<tr>
<td>PSQ</td>
<td>(PSQ1) I think that the functions of the system are reliable.</td>
</tr>
<tr>
<td></td>
<td>(PSQ2) I think that the system has up-to-date, portable hardware.</td>
</tr>
<tr>
<td></td>
<td>(PSQ3) I think that the system has an up-to-date, user-friendly interface.</td>
</tr>
<tr>
<td>PIQ</td>
<td>(PIQ1) I think that the content provided by the system is reliable.</td>
</tr>
<tr>
<td></td>
<td>(PIQ2) I think that the content provided by the system is comprehensive.</td>
</tr>
<tr>
<td></td>
<td>(PIQ3) I think that the content provided by the system is easy to understand.</td>
</tr>
<tr>
<td>PIO</td>
<td>(PIO1) I am not feeling fatigue when I use the system to visit exhibits.</td>
</tr>
<tr>
<td></td>
<td>(PIO2) I am not losing patience when I use the system to visit exhibits.</td>
</tr>
<tr>
<td></td>
<td>(PIO3) I can remember more information about exhibits of interest when I use the system to visit exhibits.</td>
</tr>
</tbody>
</table>

Participants and the system

A total of 72 visitors (46 males and 26 females) participated in the experiment, which was conducted in a university museum in Tainan City, Taiwan. The participants’ ages ranged between the age of young students to that of the elderly, as shown in Table 2. The PGR system was implemented through C# programming language and a SQL Server 2005 database. 0 shows the participants visiting the museum through the PGR system.

<table>
<thead>
<tr>
<th>Table 2. Demographic characteristics of participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>Characteristic</td>
</tr>
<tr>
<td>----------------</td>
</tr>
<tr>
<td>Gender</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Age</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Total</td>
</tr>
</tbody>
</table>
Procedure

At the start of the experimental procedure, all participants were asked to execute a visiting activity through the PGR system. In the activity, the participants used the system to visit exhibits in which the system recommended the exhibit according to their visiting behavior. When the activity was finished, the participants were asked to fill out the questionnaire.

Results and discussion

Assessment of questionnaire

Reliability

Cronbach’s $\alpha$ was used to assesses the reliability. The Cronbach $\alpha$ values in five constructs were higher than 0.70 (total Cronbach $\alpha$ value in five dimensions=0.928; the Cronbach $\alpha$ value of PEU=0.874, PUF=0.766, PSQ=0.792, PIQ=0.794 and PIO=0.895). This implies that the reliability was sufficiently high (Wortzel, 1979). Furthermore, the minimum value of each corrected item-to-total correlation was above 0.5 (minimum = 0.535), which showed that the questionnaire had strong reliability (Ong et al., 2009). The results of the reliability analysis are summarized in Table 3.

Content validity

Domain experts were used to examine the content validity. Some ambiguous or unsuitable items were modified, removed, altered, or arranged in a proper order according to the feedback from experts. This rigorous process implies that the questionnaire had good content validity.
Table 3. The results of the reliability analysis

<table>
<thead>
<tr>
<th>Construct</th>
<th>Item</th>
<th>Corrected item-total correlation</th>
<th>Cronbach’s α</th>
</tr>
</thead>
<tbody>
<tr>
<td>PEU</td>
<td>PEU1</td>
<td>0.786</td>
<td>0.874</td>
</tr>
<tr>
<td></td>
<td>PEU2</td>
<td>0.796</td>
<td></td>
</tr>
<tr>
<td></td>
<td>PEU3</td>
<td>0.709</td>
<td></td>
</tr>
<tr>
<td>PUF</td>
<td>PUF1</td>
<td>0.591</td>
<td>0.766</td>
</tr>
<tr>
<td></td>
<td>PUF2</td>
<td>0.679</td>
<td></td>
</tr>
<tr>
<td></td>
<td>PUF3</td>
<td>0.535</td>
<td></td>
</tr>
<tr>
<td>PSQ</td>
<td>PSQ1</td>
<td>0.678</td>
<td>0.792</td>
</tr>
<tr>
<td></td>
<td>PSQ2</td>
<td>0.733</td>
<td></td>
</tr>
<tr>
<td></td>
<td>PSQ3</td>
<td>0.695</td>
<td></td>
</tr>
<tr>
<td>PIQ</td>
<td>PIQ1</td>
<td>0.564</td>
<td>0.794</td>
</tr>
<tr>
<td></td>
<td>PIQ2</td>
<td>0.745</td>
<td></td>
</tr>
<tr>
<td></td>
<td>PIQ3</td>
<td>0.622</td>
<td></td>
</tr>
<tr>
<td>PIO</td>
<td>PIO1</td>
<td>0.900</td>
<td>0.895</td>
</tr>
<tr>
<td></td>
<td>PIO2</td>
<td>0.832</td>
<td></td>
</tr>
<tr>
<td></td>
<td>PIO3</td>
<td>0.690</td>
<td></td>
</tr>
</tbody>
</table>

Criterion-related validity

Criterion-related validity is used to demonstrate the accuracy of a measure by comparing it with another measure (Sartori & Pasini, 2007). It is assessed by comparing correlation coefficient test scores with the external criterion or overall satisfaction (Ong et al., 2009). For the purposes of this study, the correlation between the total scores on the questionnaire (the sum of 15 items) and the measures of criterion validity (the sum of three global items used to measure overall satisfaction with PGR) were determined. The results showed that the questionnaire had a criterion-related validity of 0.68 (P-value < 0.001), suggesting acceptable criterion-related validity (Hair, Black, Babin, Anderson, & Tatham, 2006; Ong et al., 2009).

Construct validity

Construct validity is used to validate that a questionnaire is actually a measure of what it is intended to measure (i.e. the construct) and not a measurement of other variables. It is assessed by using convergent and discriminant validity (Ong et al., 2009). The convergent validity was assessed by examining the average variance extracted (AVE), which must exceed the standard minimum level of 0.5 (Hair et al., 2006). The discriminant validity was evaluated by the square root of the AVE and the correlation matrix of the construct (Fornell & Larcker, 1981), in which the square root of the AVE of each construct should exceed the correlation shared between one construct and other constructs. The results seen in Table 4 show that most criteria exceeded the threshold suggested in previous research and thus indicated that a satisfactory construct validity was obtained. Hence, the observed assessment of reliability and validity suggest the adequacy of the questionnaire used in this study.

Table 4. The results of convergent and discriminant validity

<table>
<thead>
<tr>
<th>Construct</th>
<th>Convergent validity</th>
<th>Discriminant validity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>AVE</td>
<td>Correlation matrix of construct</td>
</tr>
<tr>
<td></td>
<td></td>
<td>PEU</td>
</tr>
<tr>
<td>PEU</td>
<td>0.81</td>
<td>0.90</td>
</tr>
<tr>
<td>PUF</td>
<td>0.68</td>
<td>0.62</td>
</tr>
<tr>
<td>PSQ</td>
<td>0.76</td>
<td>0.58</td>
</tr>
<tr>
<td>PIQ</td>
<td>0.72</td>
<td>0.52</td>
</tr>
<tr>
<td>PIO</td>
<td>0.83</td>
<td>0.46</td>
</tr>
</tbody>
</table>
Results of user satisfaction evaluation

A user satisfaction questionnaire was designed as a general survey of 15 items and consisted of five constructs (i.e., PEU, PUF, PSQ, PIQ, and PIO) on the five-point Likert scale that ranging from strongly disagree (1), disagree (2), undecided (3), agree (4), strongly agree (5). In the experiment, the questionnaire was filled out by 72 visitors, and their responses to the questionnaire are summarized in Table 5. The mean score of most of responses was greater than 4. The results are overall very positive.

<table>
<thead>
<tr>
<th>Construct</th>
<th>Item</th>
<th>Strongly agree</th>
<th>Agree</th>
<th>Undecided</th>
<th>Disagree</th>
<th>Strongly disagree</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>PEU</td>
<td>PEU1</td>
<td>40% (29)</td>
<td>49% (35)</td>
<td>11% (8)</td>
<td>0% (0)</td>
<td>0% (0)</td>
<td>4.3</td>
</tr>
<tr>
<td></td>
<td>PEU2</td>
<td>35% (25)</td>
<td>51% (37)</td>
<td>14% (10)</td>
<td>0% (0)</td>
<td>0% (0)</td>
<td>4.2</td>
</tr>
<tr>
<td></td>
<td>PEU3</td>
<td>33% (24)</td>
<td>51% (37)</td>
<td>11% (8)</td>
<td>4% (3)</td>
<td>0% (0)</td>
<td>4.1</td>
</tr>
<tr>
<td>PUF</td>
<td>PUF1</td>
<td>31% (22)</td>
<td>54% (39)</td>
<td>11% (8)</td>
<td>4% (3)</td>
<td>0% (0)</td>
<td>4.1</td>
</tr>
<tr>
<td></td>
<td>PUF2</td>
<td>42% (30)</td>
<td>40% (29)</td>
<td>13% (9)</td>
<td>6% (4)</td>
<td>0% (0)</td>
<td>4.2</td>
</tr>
<tr>
<td></td>
<td>PUF3</td>
<td>36% (26)</td>
<td>44% (32)</td>
<td>17% (12)</td>
<td>1% (1)</td>
<td>1% (1)</td>
<td>4.1</td>
</tr>
<tr>
<td>PSQ</td>
<td>PSQ1</td>
<td>29% (21)</td>
<td>28% (20)</td>
<td>21% (15)</td>
<td>19% (14)</td>
<td>3% (2)</td>
<td>3.6</td>
</tr>
<tr>
<td></td>
<td>PSQ2</td>
<td>32% (23)</td>
<td>53% (38)</td>
<td>14% (10)</td>
<td>1% (1)</td>
<td>0% (0)</td>
<td>4.2</td>
</tr>
<tr>
<td></td>
<td>PSQ3</td>
<td>35% (25)</td>
<td>57% (41)</td>
<td>8% (6)</td>
<td>0% (0)</td>
<td>0% (0)</td>
<td>4.3</td>
</tr>
<tr>
<td>PIQ</td>
<td>PIQ1</td>
<td>35% (25)</td>
<td>46% (33)</td>
<td>17% (12)</td>
<td>0% (0)</td>
<td>3% (2)</td>
<td>4.1</td>
</tr>
<tr>
<td></td>
<td>PIQ2</td>
<td>32% (23)</td>
<td>56% (40)</td>
<td>11% (8)</td>
<td>0% (0)</td>
<td>1% (1)</td>
<td>4.2</td>
</tr>
<tr>
<td></td>
<td>PIQ3</td>
<td>26% (19)</td>
<td>53% (38)</td>
<td>18% (13)</td>
<td>3% (2)</td>
<td>0% (0)</td>
<td>4.0</td>
</tr>
<tr>
<td>PIO</td>
<td>PIO1</td>
<td>29% (21)</td>
<td>36% (26)</td>
<td>26% (19)</td>
<td>8% (6)</td>
<td>0% (0)</td>
<td>3.9</td>
</tr>
<tr>
<td></td>
<td>PIO2</td>
<td>31% (22)</td>
<td>42% (30)</td>
<td>17% (12)</td>
<td>8% (6)</td>
<td>3% (2)</td>
<td>3.9</td>
</tr>
<tr>
<td></td>
<td>PIO3</td>
<td>35% (25)</td>
<td>51% (37)</td>
<td>10% (7)</td>
<td>4% (3)</td>
<td>0% (0)</td>
<td>4.2</td>
</tr>
</tbody>
</table>

Figure 7 is the radar chart for the mean scores of the five constructs. It can be observed that the mean scores of PEU, PUF, and PIQ constructs are greater than PSQ and PIO constructs. This means that the overall excellence or superiority of the PGR system still has room for improvement, especially in regard to the reliability of the functions of the PGR system (see the mean score of PSQ1 in Table 5). This is because the PGR system is a prototype system, so the reliability of the functions is relatively low. Furthermore, in the PIO construct, visitor responses to the fatigue and patience items (i.e., PIO1 and PIO2) had relatively small positive feedback, in contrast to remembrance (PIO3). This is because visitors need to consume energy when carrying a netbook computer, so the PIO1 and PIO2 had the relatively lower scores. In sum, the PGR system obtained overall positive feedback in the user satisfaction evaluation.

Comparison of user satisfaction with gender

To investigate whether gender influences user satisfaction with the PGR system, an independent sample T-test was used to examine it. According to the results of the T-test shown in Table 6, there was no significant difference
between the user satisfaction of females and males (P-value > 0.05). The results indicated that females and males were both consistently satisfied with the PGR system.

Table 6. The comparison of the user satisfaction with gender

<table>
<thead>
<tr>
<th>Construct</th>
<th>Gender</th>
<th>Mean</th>
<th>Standard deviation</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>PEU</td>
<td>Female</td>
<td>4.2051</td>
<td>0.63</td>
<td>0.94</td>
</tr>
<tr>
<td></td>
<td>Male</td>
<td>4.2174</td>
<td>0.64</td>
<td></td>
</tr>
<tr>
<td>PUF</td>
<td>Female</td>
<td>4.0128</td>
<td>0.70</td>
<td>0.24</td>
</tr>
<tr>
<td></td>
<td>Male</td>
<td>4.2101</td>
<td>0.66</td>
<td></td>
</tr>
<tr>
<td>PSQ</td>
<td>Female</td>
<td>3.8590</td>
<td>0.65</td>
<td>0.19</td>
</tr>
<tr>
<td></td>
<td>Male</td>
<td>4.0942</td>
<td>0.76</td>
<td></td>
</tr>
<tr>
<td>PIQ</td>
<td>Female</td>
<td>4.0897</td>
<td>0.53</td>
<td>0.94</td>
</tr>
<tr>
<td></td>
<td>Male</td>
<td>4.1014</td>
<td>0.73</td>
<td></td>
</tr>
<tr>
<td>PIO</td>
<td>Female</td>
<td>3.8590</td>
<td>0.84</td>
<td>0.39</td>
</tr>
<tr>
<td></td>
<td>Male</td>
<td>4.0362</td>
<td>0.83</td>
<td></td>
</tr>
</tbody>
</table>

Comparison of user satisfaction with age

To compare the user satisfaction with the PGR system among different age groups, a one-way ANOVA analysis was used. To carry out the ANOVA analysis, the participants were divided into five groups, G1 (1 - 10), G2 (11 - 20), G3 (21 - 30), G4 (31 - 40), and G5 (41 - 50), according to the demographic characteristics of the participants (see Table 2). Table 7 shows the result of the ANOVA analysis, which revealed that there was a significant difference in the PSQ construct (F-value=3.71, P-value = 0.01), though this was a relatively small effect size (eta-squared = 0.18). The results demonstrate that a significant relationship was found between PSQ and participant age.

Table 7. The ANOVA analysis of the user satisfaction with age

<table>
<thead>
<tr>
<th>Construct</th>
<th>Source</th>
<th>Sum of squares</th>
<th>Degrees of freedom</th>
<th>Mean square</th>
<th>F-value</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>PEU</td>
<td>Between Groups</td>
<td>1.51</td>
<td>4.00</td>
<td>0.38</td>
<td>0.95</td>
<td>0.44</td>
</tr>
<tr>
<td></td>
<td>Within Groups</td>
<td>26.55</td>
<td>67.00</td>
<td>0.40</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>28.07</td>
<td>71.00</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PUF</td>
<td>Between Groups</td>
<td>4.11</td>
<td>4.00</td>
<td>1.03</td>
<td>2.41</td>
<td>0.06</td>
</tr>
<tr>
<td></td>
<td>Within Groups</td>
<td>28.50</td>
<td>67.00</td>
<td>0.43</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>32.61</td>
<td>71.00</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PSQ</td>
<td>Between Groups</td>
<td>6.84</td>
<td>4.00</td>
<td>1.71</td>
<td>3.71</td>
<td>0.01</td>
</tr>
<tr>
<td></td>
<td>Within Groups</td>
<td>30.93</td>
<td>67.00</td>
<td>0.46</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>37.77</td>
<td>71.00</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PIQ</td>
<td>Between Groups</td>
<td>1.92</td>
<td>4.00</td>
<td>0.48</td>
<td>1.10</td>
<td>0.36</td>
</tr>
<tr>
<td></td>
<td>Within Groups</td>
<td>29.28</td>
<td>67.00</td>
<td>0.44</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>31.20</td>
<td>71.00</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PIO</td>
<td>Between Groups</td>
<td>2.56</td>
<td>4.00</td>
<td>0.64</td>
<td>0.91</td>
<td>0.46</td>
</tr>
<tr>
<td></td>
<td>Within Groups</td>
<td>46.94</td>
<td>67.00</td>
<td>0.70</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>49.50</td>
<td>71.00</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

To further investigate the relationship between PSQ and participants’ age, a least significant difference (LSD) comparison was used. Table 8 shows the result of the LSD comparison, which indicated that G3–G1, G3–G2, G3–G4, and G3–G5 were significantly different from each other (see the gray cell in Table 8). 0 shows the PSQ scores of the different age groups and indicates that G3 has more stringent criteria for the service quality of the PGR system than do other groups. One reason for this was inferred, which is the premise that the G3 participants were experienced with the use of computers. Considering the time during which widespread use of computers has taken place (about 30 years), G3 participants could be determined to have had the most experience with using computers as compared to the other groups because the other groups were either too young or too old. Considering the opportunity for use of computers, G3 participants had the most opportunity to use computers because the other groups were either students or retirees. Consequently, it can be assumed that G3 participants had more stringent requirements for the service quality of the PGR system due to their prior experience with computer usage.
Table 8. The comparison of the PSQ construct with age

<table>
<thead>
<tr>
<th>(I) PSQ</th>
<th>(J) PSQ</th>
<th>Mean difference (I-J)</th>
<th>Standard error</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>G1</td>
<td>G2</td>
<td>0.06</td>
<td>0.28</td>
<td>0.842</td>
</tr>
<tr>
<td>G1</td>
<td>G3</td>
<td>0.78</td>
<td>0.23</td>
<td>0.001</td>
</tr>
<tr>
<td>G1</td>
<td>G4</td>
<td>0.36</td>
<td>0.24</td>
<td>0.144</td>
</tr>
<tr>
<td>G1</td>
<td>G5</td>
<td>0.21</td>
<td>0.29</td>
<td>0.472</td>
</tr>
<tr>
<td>G2</td>
<td>G3</td>
<td>0.73</td>
<td>0.26</td>
<td>0.007</td>
</tr>
<tr>
<td>G2</td>
<td>G4</td>
<td>0.30</td>
<td>0.27</td>
<td>0.272</td>
</tr>
<tr>
<td>G2</td>
<td>G5</td>
<td>0.15</td>
<td>0.31</td>
<td>0.628</td>
</tr>
<tr>
<td>G3</td>
<td>G4</td>
<td>-0.43</td>
<td>0.22</td>
<td>0.057</td>
</tr>
<tr>
<td>G3</td>
<td>G5</td>
<td>-0.58</td>
<td>0.27</td>
<td>0.037</td>
</tr>
<tr>
<td>G4</td>
<td>G5</td>
<td>-0.15</td>
<td>0.28</td>
<td>0.599</td>
</tr>
</tbody>
</table>

Figure 8. The PSQ scores of different groups.

**Comparative analysis of museum systems**

A comparative analysis is used to evaluate the usability of the PGR system. In this analysis, we have conducted an extensive comparison between our proposed system and other museum systems. To fairly analyze these systems, only technical criteria are adopted to analyze the comparison. The adopted criteria are described in Table 9.

Table 9. The description of the criteria

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Client/Web</td>
<td>The type of museum system.</td>
</tr>
<tr>
<td>Device</td>
<td>The operating device of museum system.</td>
</tr>
<tr>
<td>Location-aware</td>
<td>Museum system provides visitors with services according to visitors’ location.</td>
</tr>
<tr>
<td>Personalized</td>
<td>Museum system provides visitors with services according to visitors’ interest.</td>
</tr>
<tr>
<td>Multimedia</td>
<td>Museum system provides visitors with multimedia presentations of exhibits.</td>
</tr>
<tr>
<td>Map</td>
<td>Museum system provides visitors with map of exhibit areas.</td>
</tr>
<tr>
<td>Management</td>
<td>Museum system provides staffs with functions to manage exhibits.</td>
</tr>
</tbody>
</table>

Since information technology advances rapidly, only the related museum systems published within recent three years are selected as candidates for the comparison. There are seven related museum systems considered in the comparison. As the PGR system is introduced in this article, the other museum systems and their features are briefly described below. Each candidate was assigned an ID in order to identify them, and Table 10 summarizes the results of the comparative analysis. From the results, MS4 are similar to the PGR system. Compared with MS4, the PGR system lacked map function, but it can simultaneously satisfy the needs of visitors and staffs. Moreover, the screen of operating device of the PGR system is bigger than that of mobile phone and PDA, and the weight of operating device of the PGR system is smaller than that of tablet PC. Accordingly, we believed that the PGR system can provide visitors and staffs with a satisfied experience.
MS1 (Sung et al., 2008): This system is a mobile guide system, which is a web-based system and operated in tablet PC. The system mainly provides visitors with map and multimedia presentations of exhibits. Here, the multimedia presentations include photo, audio, and text.

MS2 (Vavoula et al., 2009): This system is an inquiry learning system, which is the combination of web-based and client-based systems and operated in mobile phone. The system mainly provides visitors with multimedia presentations of exhibits and a set of functions for supporting their inquiry learning in museum. Here, the multimedia presentations include photo, illustration, and text.

MS3 (Pianesi et al., 2009): This system is a mobile guide system, which is a client-based system and operated in PDA. The system mainly provides visitors with multimedia presentations of exhibits and location-awareness service. Here, the multimedia presentations include audio and video; the location-awareness service signifies that the system provides visitors with the multimedia presentation according to the location of visitors.

MS4 (Ghiani et al., 2009): This system is a mobile guide system, which is a client-based system and operated in PDA. The system mainly provides visitors with map, multimedia presentations of exhibits, location-awareness service, and personalized service. Here, the multimedia presentations include audio and video; the location-awareness service implies that the system provides visitors with a path to a specific exhibit from the current location; the personalized service means that the system guides visitors to visit their favorite exhibits.

MS5 (Reynolds et al., 2010): This system is a mobile guide system, which is a web-based system and operated in PDA. The system mainly provides visitors with the multimedia presentations of exhibits, a set of functions for supporting visitors to explore museum and exhibits. Here, the multimedia presentations include photo, audio, video, and text.

MS6 (Sung et al., 2010): This system is a mobile guide system, which is a web-based system and operated in tablet PC. The system mainly provides visitors with map and multimedia presentations of exhibits. Here, the multimedia presentations include photo, audio, and text.

<table>
<thead>
<tr>
<th>Criteria/Museum system</th>
<th>PGR system</th>
<th>MS1</th>
<th>MS2</th>
<th>MS3</th>
<th>MS4</th>
<th>MS5</th>
<th>MS6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Client/Web</td>
<td>Client</td>
<td>Web</td>
<td>Client &amp; Web</td>
<td>Client</td>
<td>Client</td>
<td>Web</td>
<td>Web</td>
</tr>
<tr>
<td>Device</td>
<td>Netbook computer</td>
<td>Tablet PC</td>
<td>Mobile phone</td>
<td>PDA</td>
<td>PDA</td>
<td>PDA</td>
<td>Tablet PC</td>
</tr>
<tr>
<td>Location-aware</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Personalized</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Multimedia</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Map</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Management</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
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<td>No</td>
<td>No</td>
<td>No</td>
</tr>
</tbody>
</table>

**Conclusion**

Museum learning has considerable potential for informal learning, but IO is harmful to museum learning. In this paper, we developed a PGR system to assist visitors in engaging in such learning. The system applied collective and individual visiting behavior to recommend personalized guides for visitors. In this way visitors are capable of avoiding a situation of dealing with a large number of exhibits; that is to say, IO could be eased through a personalized guide. To explore user satisfaction with the PGR system, a user satisfaction questionnaire was developed. The assessments of reliability and validity demonstrated that the questionnaire was appropriate for further analysis of its results. The results showed that the PGR system obtained overall positive feedback among both females and males. In the meantime, the relationship between system service quality and user age was found to be significant. The users’ prior experience with computer use was inferred to be the main factor contributing to this relationship.

Although the proposed system had demonstrated benefits, some problems remain and should be addressed in future research. In this study, the category that occurred the most frequently among visited exhibits was used as user interest. However, the time for visiting exhibits also needs to consider because visitors may spend a small amount of time visiting many exhibits for which they have little interest. Moreover, the presentation style of the system also needs to be considered since visitors’ ages ranged from very young students to the elderly. In future work, we will attempt to design a new way to recommend a personalized guide and present different display styles for visitors. Finally, the value of $\text{cat}(Vc, REc)$ may be too discrete (either 0 or 1). In the current research, we focused on using the
system for recommendation purpose in order to mitigate information overload in museum learning, and thus the current discrete setting seems good enough to achieve the current purpose. However, in the future research, we will modify the value of \( \text{cat}(Vc, REc) \) to a real value in order to more accurately recommend personalized guides for visitors.

The limitations of this study include the types of measurements and the relatively small sample size. In this study, all of the measurements were limited to the visitors’ self-reported perceptions. In future work, we will introduce additional measurements to explore the relationship between the PGR system and museum learning effectiveness. Furthermore, increasing the sample size to obtain stronger evidence for the proposed PGR system will be expected as well.

Acknowledgments

The authors would like to thank the National Science Council of the Republic of China for financially supporting this research under Contract No. NSC 97-2511-S-006-001-MY3, NSC 99-2631-S-011-002, NSC 99-2631-S-006-001, NSC 100-2511-S-006-015-MY3, NSC 100-2511-S-006-014-MY3, and NSC 100-2631-S-006-002-.

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affiliation network models as a collaborative filtering mechanism in e-learning. Interactive Learning Environments, 19(4), 317-331. doi: 10.1080/10494820903148610


Assessment of 3D Viewers for the Display of Interactive Documents in the Learning of Graphic Engineering

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ABSTRACT

The purpose of this study is to determine which 3D viewers should be used for the display of interactive graphic engineering documents, so that the visualization and manipulation of 3D models provide useful support to students of industrial engineering (mechanical, organizational, electronic engineering, etc). The technical features of 26 3D visualization software programmes (viewers, publishers, 3D output formats) are examined, to select the three visualization configurations that best meet our needs at the Graphic Expression Department of the University of Burgos (Solidworks plus Solidworks eDrawings; Catia plus Catia eDrawings and 3DXML; several Computer-Aided Design software programmes plus Adobe Acrobat Pro Extended). These are compared using the Quality Function Deployment tool known as House of Quality. The House of Quality has enabled us to identify and quantify the importance attached by engineering teachers to each of their requirements for 3D viewers, and to identify and quantify the technical importance of each of the measurable features of these viewers.

Keywords

Web3D, Virtual interactive learning, Viewer, 3D interactive documents

Introduction

Throughout their learning processes at our university, students of mechanical, organizational and electronic engineering use Computer-Aided Design (CAD) packages in various CAD/Computer-Aided Engineering (CAE)/Computer-Aided Manufacturing (CAM) studies. It is necessary to develop spatial visualization ability when the computer is used as a design tool, in order to be able to see and understand the operation of the complex mechanisms in the CAD package. This visualization ability must be developed during the initial stages of the engineering learning process. Spatial representation systems were the tools used to develop this ability until the introduction of CAD packages. Nowadays, the acquisition and development of spatial visualization ability requires autonomous learning, learning that uses educational platforms, and within graphic engineering, a common tool that is independent of any software (3D viewers) and which makes it possible to review the 3D models.

An early trend still in use today in the viewing of 3D models is to insert them directly into the website using a plug-in. Initially, the most commonly used standard format, VRML (Virtual Reality Modelling Language) was normally used, in web environments, in viewers such as Cosmo Player and Cortona. This VRML format has not been developed any further since 1997, but it has been used in various graphic engineering teaching applications, such as the visualization workshop at the University of Burgos (Ramos Barbero et al., 2003), in mental rotation exercises for the development of spatial abilities (Rafi, Anuar, Samad, Hayati, & Mahadzir, 2005), and in the ME-105 “Computer Aided Engineering Graphics” course at the Middle East Technical University of Turkey (http://www.me.metu.edu.tr/courses/me105/Outlineindex/outlineindex.htm). The “WEBD” project, designed under the Leonardo da Vinci International Programme, also used the VRML format initially, but in its new “3DWebEPL” version (http://www.gig.etsii.upm.es/moodle) it uses several viewers such as 3DVIA-Composer, Viewpoint Media Player and eDrawings (Ciobanu, Tornincasa, & Ciobanu, 2009).

A new ISO standard—eXtensible 3D (X3D) Graphics (Web 3D Consortium, 1999)—is the next generation VRML language. X3D constitutes an improvement over VRML and opens up a wide range of applications for web-based collaborative visualization in distributed product development. For example, Chih-Hsing Chu (Chu, Cheng, & Wu, 2006) has developed an application, in which it is possible to view various configurations of a 3D product using SpinFire (collaborative visualization utilities), an applications server, and a PDM system.
Choosing the most suitable viewer in a particular environment, with specific needs in mind, is not a simple. We have to bear in mind the following four points: the CAD package in use; whether a 3D publisher is integrated into the CAD software or whether an external one is used; whether a viewer or a plug-in is used; and its format type. In the engineering applications environment, Ron LanFon (LaF on, 2007) assesses the features of the following 3D publishers: SpinFire, Adobe Acrobat 3D, MYRIAD, XVL Studio Pro, QuadriSpace, Right Hemisphere and eDrawings, most of which have trial versions and free viewers.

In the teaching/learning of graphic engineering we can also use these viewers for the manipulation of parts and mechanisms in the initial learning of visualization skills and in the subsequent self-review of various exercises by the students themselves. The manipulation of 3D models using viewers is also useful to us in teaching, in understanding the operation of the devices and their assembly, if these have their simulations incorporated, but unfortunately, there is no standard viewer that covers all web-based 3D information sharing needs. An early study aimed at assessing the features of viewers with regard to their use in teaching was carried out by Tornincasa (Tornincasa & Chirone, 2002). This study compares the viewing tools of 3DAnywhere, cult3D and Viewpoint. A second large study comparing the various Web3D tools was carried out by Vezzetti (Vezzetti, 2009). This examines the features of the following tools: WEB3D-CDF, 3Dif-U3D, Actify-3D, SolidWorks-eDrawings, Cycore-C3D, Viewpoint-mTx, RealityWave-XGL, Lattice3D-XVL, UGS-JT, Cimmetry-CMF, and Tech Soft America-HSF.

The technologies of Web3D formats use CAD 3D models without the use of CAD software. This reduces the size of their files considerably and maintains many of the properties of the models in the CAD, to make it possible to measure distances, add information, manipulate the viewpoint and the zoom, hide/show components, view sections, create animations, etc. The integration of this information and knowledge in the Web3D models into any document is very useful in our students’ learning processes, because studying the movements of the various components and devices helps the student to develop spatial visualization, and to understand functional analysis and the assembly of its various components. A third study compares the properties of seven Web3D tools for an e-learning training course in the field of mechanical engineering. This study was carried out by Violante (Violante, Vezzetti, Tornincasa, Bonisoli, & Moos, 2009) and compares the following Web3D tools: Adobe Acrobat 3D, Anark Core, 3DVIA composer, XVL Studio Pro, Cortona 3D, QuadriSpace document3D and Viewpoint Media Player. Violante uses the 3D models in the eDrawings format of the 3DVIA composer technology for his CAD e-learning course as a Web3D tool on the Moodle platform.

A second, current trend in Web3D is becoming increasingly popular and involves the use of electronic documents (for example *.pdf and *.doc formats) which have 3D models integrated into the images, and where it is possible to view and manipulate the 3D models within the electronic document, applying a different plug-in according to the CAD publishing/visualization software in use. The authors of this paper believe that interactive documents are one of the most important web-based resources for the learning of graphic engineering.

For all the above reasons, the subject of this study concerns the right choice of 3D viewers which, bearing in mind our particular requirements, will enable us to manipulate 3D models in documents, within the graphic engineering learning process.

**Pedagogical rationale**

The fundamental theory that motivates the educational use of EVEs (Educational Virtual Environments) is constructivism. As pointed out by Harper (Harper, Hedberg, & Wright, 2000), apart from reality, the most appropriate way to generate a context based on authentic learner activity may be through the use of EVEs. Following this theory, interaction with the world is relevant for the learning process. For this reason, Web3D technologies, which give great interaction, flexibility and portability are used in an educational context in various ways: formal education, informal education (for example, visits to virtual museums), distance or electronic learning and training. In general, EVEs can provide a wide range of experiences, some of which could never be observed in the real world, such as the internal operation of machines through virtual simulation, for which it is necessary to cut open machines or make certain pieces transparent. An important advantage concerns the use of three dimensional graphics, which allows for more realistic and detailed representations of topics, offering more viewpoints and more inspection possibilities than 2D representations. In many educational contexts (e.g., engineering), this can be crucial to our acquiring a better understanding of topics (e.g., the internal combustion engine).
A significant number of the students who enter our university have fairly undeveloped spatial abilities. This is mainly because technical drawing is only an optional subject in further education in Spain. According to Saorin (Saorín Pérez, Navarro Trujillo, Martín Dorta, Martín Gutiérrez, & Contero, 2009), spatial ability is the ability to manipulate objects and their parts mentally in space. Spatial ability is divided into two categories: spatial relations, in which the ability to rotate and compare models is developed; and spatial vision, in which the ability to manipulate complex visual information is developed (various stages being needed to obtain the solution), such as the recognition of an item by folding and unfolding its faces. Students who need to improve their spatial abilities can be helped by using test collections such as DAT-SR (Differential Aptitude Test in Spatial Relations), PSVT:R (Purdue Spatial Visualization Test: Rotations) and MRT (Mental Rotations test), by using interactive games or spatial visualization workshops, and by performing exercises with the real items in augmented reality or virtually on a computer. It is necessary to use a 3D viewer which meets the learning needs of our students, in order to be able to view and manipulate the 3D models virtually on the computer, which assists our students in the development of their spatial abilities. The 3D viewer that is chosen must therefore be a tool which makes it possible to view and manipulate 3D models, in order to further develop the spatial abilities of graphic engineering students.

Sorby (Sorby & Baartmans, 1996), in the conclusions to a course on 3D visualization abilities, concluded that performing exercises by computer (in his case with I-DEAS software) improved the learning processes of those students who had the greatest learning difficulties. Significantly, Rafi (Rafi et al., 2005) confirmed that the use of Web3D applications as a teaching tool with 3D models in the VRML format improved the development of spatial abilities. Other investigations, however, such as that of Koch (Koch, 2006), have shown that there are no significant differences between sketching and solid-modelling design methods used for technical problem solving.

ICT (Information and Communications Technology) is essential to enable innovation in the communication methods between students and teachers, and the use of learning-based teaching techniques for our students, within the EHEA (European Higher Education Area) (Barajas & Owen, 2000). Investigation into educational techniques and systems associated with the use of Web3D is very limited, and there is great potential for a large number of educational applications that require visual understanding (Strong & Smith, 2001), (Web 3D Consortium, 1999). It should be noted that more emphasis has been given to the visualization of 3D objects, because 3D immediately enhances the learning process (Liarokapis et al., 2004). Students can explore a 3D visualization of the teaching material, thus enabling them to understand more effectively through interactivity with Web3d content. It is believed that the experimental scenarios presented can provide a rewarding learning experience that would otherwise be difficult to achieve.

Nevertheless, as Chittaro (Chittaro & Ranon, 2007) affirmed, we must not forget some of the limitations of Web3D technologies in the use of EVEs. These include the teachers’ lack of experience or interest in using them, and the fact that their browsers are not always intuitive or easy to use. Furthermore, these Web3D technologies are not cheap and there is no standard method of assessing them (which means that some of their features may be of little relevance). It should also be remembered that using these technologies may have a demotivating effect on certain students.

**Definition of the most important requirements in 3D viewers**

The Quality Function Deployment (QFD) method is used here, in order to determine the most important items required of 3D viewers for the constructivist learning process in graphic engineering and to see how well these needs are met by the 3D viewers that are currently available on the market. This method is based on identifying the needs of the customers and, in our case, the needs which the viewers are required to meet for the purposes of teaching and learning.

There are studies which identify these needs from perspectives other than our own. For example:

- Tornincasa (Tornincasa, Vezzetti, Calignano, & Moos, 2008), having interviewed workers using CAD/CAM/CAE tools in engineering and manufacturing companies, found that the 4 most important requirements are views, sections, dimensions, and dimensional and geometric tolerances.

- Ortega (Ortega Izquierdo, 2002) used the QFD method to assess digital mock-up systems—Enovia DMU and VisMockup—in three departments of a multinational company in the car industry. It was found that the digital mock-up systems had to meet the following requirements: easy installation, multiplatform modes, precise
Table 1. Survey on the features required of 3D viewers

<table>
<thead>
<tr>
<th>Features required of 3D viewers for the teaching of Engineering</th>
</tr>
</thead>
<tbody>
<tr>
<td>Please indicate with an X the option (A, B, or C) which you consider appropriate for each of the features required of a 3D viewer for a teaching platform.</td>
</tr>
<tr>
<td>Requirements</td>
</tr>
<tr>
<td>----------------</td>
</tr>
<tr>
<td>VISUALIZATION</td>
</tr>
<tr>
<td>1 Rendering and rendering control</td>
</tr>
<tr>
<td>2 Visualization (slides, scenes, edges, etc.)</td>
</tr>
<tr>
<td>3 Prefixed and standard views</td>
</tr>
<tr>
<td>4 Control of visualization of drawings</td>
</tr>
<tr>
<td>5 Visualization of annotations and dimensions</td>
</tr>
<tr>
<td>MANIPULATION</td>
</tr>
<tr>
<td>6 Zoom, movement and rotation (free or on the axis line)</td>
</tr>
<tr>
<td>7 Cuts and dynamic sections</td>
</tr>
<tr>
<td>8 Measurement</td>
</tr>
<tr>
<td>9 Creation of annotations and dimensions</td>
</tr>
<tr>
<td>10 Precision (measurement)</td>
</tr>
<tr>
<td>DOCUMENT AND WEB INTEGRATION</td>
</tr>
<tr>
<td>11 Educational platforms (Moodle, etc)</td>
</tr>
<tr>
<td>12 In the web, multibrowser</td>
</tr>
<tr>
<td>13 In office, pdf, open office, etc</td>
</tr>
<tr>
<td>EXCHANGE OF FORMATS AND FILE PROPERTIES</td>
</tr>
<tr>
<td>14 Small file size</td>
</tr>
<tr>
<td>15 Importing and exporting (variety of formats)</td>
</tr>
<tr>
<td>16 Printing</td>
</tr>
<tr>
<td>17 Security of intellectual property (watermark, signature)</td>
</tr>
<tr>
<td>18 Opening without downloading, multiple in the case of simultaneity</td>
</tr>
<tr>
<td>19 Loss of information (surfaces, centres, precision)</td>
</tr>
<tr>
<td>PERFORMANCE OF SOFTWARE</td>
</tr>
<tr>
<td>20 Low response time</td>
</tr>
<tr>
<td>21 Speed of opening of files</td>
</tr>
<tr>
<td>22 Minimum hardware requirements</td>
</tr>
<tr>
<td>23 Simple intuitive handling</td>
</tr>
<tr>
<td>24 Low price (freeware if possible)</td>
</tr>
<tr>
<td>25 Simple installation</td>
</tr>
<tr>
<td>MECHANISMS AND ASSEMBLIES</td>
</tr>
<tr>
<td>26 Manipulation of components</td>
</tr>
<tr>
<td>27 Decomposition and contraction of the mechanism</td>
</tr>
<tr>
<td>28 Animations</td>
</tr>
<tr>
<td>29 Hiding of components</td>
</tr>
<tr>
<td>30 Distinguishing between components in cuts and sections</td>
</tr>
</tbody>
</table>

THANK YOU FOR YOUR COOPERATION.

Table 2. The features required of 3D viewers – The Results

<table>
<thead>
<tr>
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<td>TABLE 2. The features required of 3D viewers – The Results</td>
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THANK YOU FOR YOUR COOPERATION.

To ascertain the importance of the items required in these 3D viewers, the survey shown on Table 1 was sent by e-mail to 82 teachers at 40 Spanish universities who work in the field of graphic engineering and who were selected, in view of their bibliographies, teaching, and research work in areas that involve the use of 3D CAD and 3D viewers. 54 teachers from 29 universities provided responses to the survey.

The most important items required of 3D viewers with regard to the learning of Graphic Engineering have been defined by the authors of this paper as a team and are given in Table 1. They take into account the above-mentioned studies and the needs of the teachers at our university. The 30 most important needs are divided into 6 sections: visualization, manipulation, document and web integration, format exchange and file properties, performance of software and mechanisms and assemblies.
The results of the survey on 3D viewers are shown on Table 2 in which 5 points are given to Option A (essential), 3 points to Option B (necessary), and 1 point to Option C (desirable). This table shows that the three most important requirements were considered to be: zoom, movement and rotation (free or on the axis line) with 4.55 points; simple, intuitive handling (4.13 points); and, predefined and standard views (4.09 points). The maximum possible would, of course, have been 5 points.

Selection of the 3D visualization configurations to be analysed

First of all the technical features of 26 softwares for 3D visualization were studied (viewers, publishers and 3D output formats): Adobe Acrobat Pro Extended, RxView, SpinFire Professional, MYRIAD, XVL Studio Pro, Publisher3D Professional and Pages3D Professional, Deep Exploration CAD Edition, eDrawings Professional, 3DVIA Composer, Anark Core Workstation, Cortona 3D viewer (Parallelgraphics), Viewpoint Media Player, Kaon Web3D, Hoops Stream Toolkit, 3D XML player, AutoVue (Oracle), Meshlab, OneSpace Designer – 3D Access, 3DTool, Alters 3D, Cult3D (Cycore Systems), Delcam Exchange, 3DVIA-printscreen, Autodesk ® Design Review, COLLADA, Interactive Product Animator (IPA).

As a consequence of this initial study, we realized that in the process of selecting 3D viewers for teaching purposes it is necessary to take into account not only the specific visualization softwares but also all the items that are involved in the process, namely the CAD package (SolidWorks, Catia, Solid Edge, Inventor, Pro/Engineer, NX, etc.), the publisher, the output format (3D XML, VRML, COLLADA, etc.), the viewer/plug-in (eDrawings, MYRIAD 3D Reader, etc.), and the format of the document. Bearing in mind these items, we have considered two alternatives (Figure 1): the first is generated from the CAD model which is exported to a visualization format and, by means of the appropriate viewer or plug-in, is integrated into the document; and, in the second, a publisher which accepts the CAD format and exports it to a format which is compatible with the model or type of document is also needed.

Following an initial study of the technical features of the 26 softwares, and taking into account the above two alternatives, the CAD packages available, and the possibility of having documents with interactive 3D models, we selected three cases of 3D viewer configurations for the learning of graphic engineering. These are:

- **Configuration A** (Figure 2). Exporting the models in eDrawings format from SolidWorks. The files obtained keep the animations and review tools of the CAD models (Figure 3 and Annex 1) and it is possible to manipulate the models with the eDrawings freeware viewer which can be downloaded from http://www.edrawingsviewer.com/pages/programs/download/.

The strongest points of configuration A are as follows: easy insertion of 3D models in Office and Internet, freeware viewer, and importing of animations generated in SolidWorks.
- Configuration B (Figure 4). First of all, the models are exported from Catia to 3DXML format, and by means of the 3D XML Player freeware viewer (which can be downloaded at http://www.3ds.com/es/products/3dvia/3d-xml/1/), the models can be manipulated and the Catia generated animations (Figure 5 and Annex 2) are kept, with easy integration into Office documents and into the web, but without review tools. 3DXML is a proprietary 3D file format developed by Dassault Systèmes under its 3D Via Brand; it uses an XML container whose specifications were published but it should not be confused with X3D, which is the ISO standard XML-based file format for representing 3D.
The strong points of the 3DXML output formats are: easy insertion of 3D models into Office and Internet, the viewer is freeware, and the importing of animations generated in CATIA. But the package does not, however, have basic model review tools such as measuring or making cuts and, furthermore, only SolidWorks and CATIA export in 3D XML.

In the second stage, the eDrawings Publisher integrated into Catia (Figure 4) allows the CAD model to be exported in the eDrawings format, and review tools (sections, measurements, annotations, etc) are now incorporated in the eDrawings freeware viewer. The file can be integrated into Office or web documents. We now need two files, however, to do the same thing. The Catia and SolidWorks eDrawings files are almost identical, except that former do not convert the animations or the disassembly.

If the documents are needed in *.pdf format, it is more appropriate to use Configuration C (below) than to convert the Configuration A and B Office documents to *.pdf format because in the conversion we lose all the options of interaction with the 3D model in the *.pdf document.

- **Configuration C** (Figure 6). In this configuration, we start from a model generated with the available CAD 3D software. The model is kept in the predefined format of that particular CAD 3D software, to be imported later on into the Adobe Acrobat Pro Extended publisher (http://www.adobe.com/products/acrobatproextended/) (Figure 7). If it is necessary to include animations, these are generated with Adobe 3D Reviewer (Figure 8 and Annex 3) and may be exported in *.pdf format with option U3D ECMA 1 activated.

![Figure 6. Configuration C](image_url)

![Figure 7. Example of annotation in Adobe Acrobat Pro Extended](image_url)

![Figure 8. Example of animation in Adobe 3D Reviewer (Annex 3).](image_url)

The most popular CAD and neutral formats can be imported directly into Adobe Acrobat Pro Extended, but if any type of file is not imported, the 3D files can be converted to the neutral U3D format from the CAD package, it is...
imported in Adobe Acrobat Pro Extended and stored in the pdf file. Universal 3D (U3D) is a compressed file format standard for 3D computer graphics data. The format was later standardized by the Ecma International Technical Committee 43 (TC43) as ECMA-363 (ECMA, 2007). In 2007, TC43 added support for Uniform and Non-Uniform, Rational and Non-Rational Free-Form Curves and Surfaces. It does however have important limitations such as the fact that the meshes must always be triangles. The U3D format can be edited in Adobe 3D Reviewer.

The strong points of Configuration C are as follows: It accepts most CAD formats. It works with the U3D format and generates a very good rendering appearance. However, it does not import the animations created in the CAD packages and it is necessary to create them with Adobe 3D Reviewer.

When the eDrawings files are exported to html format, eDrawings review tools may be used, but if they are inserted into an Office document, it only allows the use of basic visualization and manipulation tools, not the review tools. When the Office documents are converted to *.pdf they lose the 3D options. However, the installation of Adobe Acrobat Pro Extended adds an Adobe toolbar to Office, which enables us to embed 3D models from the native CAD packages in Office, maintaining the visualization and manipulation options of the 3D models. Only Office users who have installed the Adobe Acrobat Pro Extended package can manipulate these 3D models correctly.

Moreover, we can convert the Office file to a *.pdf file. These models can be viewed and manipulated with Adobe reader Version 7 and above, without the Adobe Acrobat Pro Extended package.

However, if the CAD 3D models are embedded directly in Adobe Acrobat Pro Extended the review options are lost. The visualization and manipulation options are maintained although it is necessary to do the animations with the Adobe 3D Reviewer module. These 3D models in Adobe can also be viewed with Adobe Reader versions above 7 and the review options are lost (measurement, sections and 3D commentaries).

**Method of assessment of the 3D viewers**

To compare the features of the three viewer configurations selected, we used “House of Quality,” which is part of Quality Function Deployment (QFD). House of Quality (HQ) is a diagram, resembling a house, used for defining the relationship between customer desires and the capabilities of the firm/product. It utilizes a planning matrix to relate what the customer desires to how a firm (which produces the products) is going to meet those desires. It is reported to increase cross-functional integration within organizations using it, especially with marketing. It therefore enables us to make a competitive comparison of the configurations of the viewers that are on the market.

*Table 3. House of Quality*
The basic structure of HQ is a table with "whats" as the labels on the left and "hows" across the top (Table 3). The roof is a diagonal matrix of "hows vs. hows" and the body of the house is a matrix of "whats vs. hows." We used a simplified house of quality, without correlations, as we did not use the house of quality as a tool for designing a new product but to compare existing software packages.

To begin the construction of the HQ, we identified and listed the customers’ requirements (the “whats”). In our case, the customers were teachers who were experts in 3D CAD in the Graphic Expression areas of various Spanish universities. We also had to bear in mind the fact that the viewers under assessment were to be used for virtual learning. Based on our knowledge of customer needs, we will determine their demands and requirements vis-à-vis the products under assessment; in short, their expectations. The results of the survey, shown on Table 2, reveal the relative importance of the "whats" demanded by the customers.

The “hows” are expressed perpendicularly to the “whats”, and each “how” is a measurable feature of a “what”. For each “what” at least one measurable “how” should be identified (Table 4 or Annex 4). These “hows” were also identified by the authors in a group discussion in which they considered the earlier study by Ortega (Ortega Izquierdo, 2002).

The relationships between the above mentioned “whats” and “hows” are shown on the relations matrix using numerical symbols, which indicate the strength of the relationship (\( \triangle 1=\text{weak}, \bigcirc 3 =\text{medium}, \bullet 9 =\text{strong} \)).

The absolute importance of each “what” is obtained by adding up the values 1, 3 and 9 on each of the squares in the “what” row, and the result obtained is multiplied by the importance score of the “what” that was obtained in the customer survey. Calculated this way, the absolute importance of each “what” provides a vision of the overall importance of each customer requirement. It tells us how important each of the characteristics required of the viewers is, considering the importance attached by the customers to each “what” and the added importance of the “how” relationships.

The absolute importance of each “how” is obtained by multiplying the values (1, 3 and 9) of each square in the column by the result of each of the values of the “whats” obtained in the survey, and adding up all the values (Cuatrecasas Arbós, 1999). Calculated this way, this importance of the “hows” tells us how important each product feature is; in our case the features of the viewers.

Finally, we add the columns to the HQ of the three viewer configurations under assessment, attributing values of 0 to 10 to each of the “whats” that are assessed in each configuration. These columns, which are also known as competitive assessment columns, tell us the strong points and weak points of each of the configurations.

The final value of each configuration is determined by the weighted average of the absolute importance of each “what” and the assessments made of each requirement (what).

**Results of the assessment of the 3D viewers**

The results of the assessment of the viewers are shown in the HQ table (Table 4 or Annex 4) in which the values of the matrix of the relationships (weak, medium and strong) between the “whats” and the “hows”, and the assessments of each of the “whats” of each of the three configurations have been obtained separately by each of the three authors. A discussion then took place in which each teacher explained his/her assessments and an overall score was allocated to each.

The scores from 0 to 10 points in the “whats” or requirements for the three configurations, A, B and C, were allocated as follows:
- 0 points, if a configuration totally fails to meet the requirement.
- 3 points, if it does not completely meet the requirement and requires the installation of accessories.
- 5 points, if it meets the requirement but it requires accessories or if it only half meets the requirements. And, so on, up to 10 points.
• 10 points, if it fully meets the requirement.

To assess the configurations we used the same 3D models on the different CAD softwares.

During the experiment, the following noteworthy points emerged:

• **Configuration A.** The eDrawings files obtained from SolidWorks do not have render control; it allows adequate visualization, manipulation and review of pieces and assembly; the eDrawings can be integrated into a Microsoft Office document (but not in the Power Point presentation) losing model review options and animations (Open file: “Annex 5 example configuration_A.doc”); drawings can be included. But if this document is exported to *.pdf, all the information is lost.

• **Configuration B.** It is necessary to install the Catia eDrawings software in Catia to obtain the models in eDrawings format; the animations created are lost on exporting to eDrawings; from Catia it is possible to export in 3DXML format to obtain the simulations and with a plug-in it is possible to manipulate the model with fewer options in the viewer; the 3DXML files in the Microsoft Office documents can be used to see the animations (Open file: “Annex 6 example configuration_B.doc”); and Configuration B behaves in the same way as Configuration A with regard to the loss of interactivity on exporting the Microsoft Office document to *.pdf format.

• **Configuration C.** Adobe Acrobat Pro Extended accepts most CAD software formats; it does not directly insert the CAD software animations although they can be generated with the 3D Reviewer module in Adobe Acrobat Pro Extended; the visualization tools are more numerous in the *.pdf document than in the Microsoft Office document; and for the users of these 3D models in *.pdf, we only need Adobe reader Version 7 and above, and these are freeware (Open file: “Annex 7 example configuration_C.pdf”).

The HQ not only enables us to make a diagnosis of the design of a product, it also enables us to make a quantitative comparison of products on the market, in our case 3D viewers for use in the learning of graphic engineering. By using the HQ (Table 4 or Annex 4), we identified the most important “whats” and “hows” to be taken into account when selecting viewers. These are shown below.

The most important technical features that the viewers should possess are as follows:

• Ease of handling.
• Integration into documents and web (Microsoft Office, Adobe Acrobat, educational platforms and various browsers).
• Variety of visualization modes (visible edges, hidden edges, etc.)
• Speed of manipulation.
• Ability to view dimensions and annotations.

A study of the averages of the requirements of the customers shows that the following are essential:

• Predefined and standard views.
• Control over the visualization of drawings.
• Zoom, movement and rotation (free or on the axis line)
• Importing and exporting (variety of formats).
• Simple, intuitive handling.
• Price (freeware if possible).
• Manipulation of components.
• Hiding of components.
• Distinguishing between components in cuts and sections.

The most important requirements of the customers, based on the survey of teachers and the matrix of relationships with the “hows,” are shown in the “absolute importance of the “whats” column. These are markedly different from the survey values and are as follows:

• Exchange of formats: importing and exporting (variety of formats).
• Manipulation by means of: zoom, movement and rotation (free or on the axis line), cuts and dynamic sections.
• Simple, intuitive handling of the viewer and rapid response time.
• Control of visualization (transparencies, scenes, modes), and predefined and standard views within the visualization.
Table 4: House of quality: assessment of viewers
The overall competitive assessment of the three configurations -A=7.5 points, B=6.7 points and C=7.1 points- is obtained as a weighted average of the “whats,” evaluated for each configuration in accordance with the absolute importance of each “what” (Table 4 or Annex 4). This score is high in Configurations A and C, without any significant difference between these. The score given to Configuration B is acceptable. As the differences in the scores are not great, the choice of configuration would generally be more a question of the CAD software used and the type of interactive document into which one wished to introduce the 3D model.

It is necessary to bear in mind, in order to understand the results shown in table 4, that:
- The column “results of the survey: mean” is obtained from the last column in table 2.
- The column “token importance” is a conversion of the earlier column into: A(essential), B(necessary) and C(desirable).
- The relations between the “whats” and the “hows” (Central matrix of the table) are valued as: 1 point for weak relations (Δ), 3 points for average relations (⊙) and 9 points for strong relations (●).
- The column absolute importance of the “whats” is obtained by adding the relations of the “whats” and the “hows” of each row of the relations matrix, and its result is multiplied by its corresponding one in the column “results of the survey:mean”.
- The row of the absolute importance of the “hows” is obtained from the addition of the products of the elements in the column “results of the survey: mean” by the corresponding elements in the column of the relations matrix.
- The points given for the evaluation of the “whats” in the three configurations range from 0 to 10 points. The final score of each configuration is obtained as a weighted measure of the value assigned to each “what” in that configuration, the weights being the elements of the column “absolute importance of the whats.”

**Conclusions**

The survey completed by 54 teachers with knowledge of CAD has shown the importance of the 30 requirements, which we had initially selected for use in the learning of graphic engineering, classed as: essential, necessary and desirable (Table 2). From the survey of teachers (Table 2) the following “whats” are considered essential: predefined and standard views; control of visualization of drawings; zoom, movement and rotation (free or on the axis line); importing and exporting (variety of formats); simple, intuitive handling; price (freeware if possible); manipulation of components; hiding of components; the distinction between components in cuts and sections.

The House of Quality is a tool which has enabled us to identify and quantify the absolute importance attached by the customers to each requirement (what), and to identify and quantify the technical importance of each of the features (how) (Table 4). It confirmed that the “whats” of greatest absolute importance in decreasing order are: -exchange of formats: importing and exporting (variety of formats); -manipulation by means of: zoom, movement and rotation (free or on the axis line), cuts and dynamic sections; -simple, intuitive handling of the viewer and rapid response time; -control of visualization (transparencies, scenes, modes), and predefined and standard views within the visualization. And the “hows” of greatest absolute importance in decreasing order are: ease of handling; integration into documents and web (Microsoft Office, Adobe Acrobat, educational platforms and various browsers); variety of visualization modes (visible edges, hidden edges, etc.); speed of manipulation; ability to view dimensions and annotations.

After assessing the technical features of 26 3D visualization software (viewers, publishers and 3D output formats), the following 3 configurations were selected and compared using the house of quality: A) SolidWorks plus SolidWorks eDrawings, B) Catia plus Catia eDrawings and 3DXML, and C) various CAD softwares plus Adobe Acrobat Pro Extended. The three viewer configurations are suitable for our purposes. Although we first intended to compare 3D viewers we discovered in the course of the exercise that the use of one or another viewer is affected by the CAD software, the publisher, the formats, the viewer and the type of document. It is for this reason that we advise:
- The use of configuration A for html files or files for independent visualization.
- The use of configuration B for files in Office format, where it is necessary to combine two files: an *.edrawing file and another *.3dxml file.
- The use of configuration C for files in pdf format.
To bear in mind when selecting the visualizer the two alternatives for the implementation of the visualizers (Figure 1): compatibility with the export formats of the CAD packets in use (3D, XML, U3D), and compatibility with the multicad publisher in use and its export format.

Overall, similar scores were allocated to the three configurations but from our experiments we can say that the following differences exist between them:

- The eDrawings viewer has a greater number of design review tools from the engineering point of view. It is possible to export to eDrawings format from most CAD softwares. The animations created in SolidWorks are kept in the eDrawings format, but not those created in Catia.
- The 3DXML format is a format of Dassault Systèmes (owner of SolidWorks and Catia) which keeps the animations of the models but does not have a model review tool (such as, for example, measure).
- The *.pdf files obtained with Adobe Acrobat Pro Extended accept most CAD formats, though the Adobe package does not convert the animations from the CAD models and has a greater number of visualization and manipulation tools, but from the perspective of a general purpose CAD software.

Finally, we may say:

- that the visualization of the 3D models, in these three visualization configurations, by students, does not need the original CAD software, and the students need do no more than download a plugin for configurations A and B, which is without charge.
- that the user interfaces of these visualizers are intuitive and easy to use by people that are not experts in the matter, thereby eliminating some of the limitations advanced by Chittaro (Chittaro & Ranon, 2007).
- that the animations in the 3D visualizer takes up values of at least 1/100 with respect to the same animation in a video file with a 800x600 pixel resolution. Hence, online Internet visualization of animations with the 3D visualizers is immediate.

References


179


Using Podcasting to Facilitate Student Learning: A Constructivist Perspective

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ABSTRACT

The paper employs two case studies to develop an approach for using podcasts to enhance student learning. The case studies involve two cohorts of postgraduate students enrolled on a blended course, over two years. In both cases, the institutional learning management system was used as a server to host the podcasts, giving students discretion on how and when to listen to podcasts. The podcasts were integrated in learning design hence tightly coupled in pedagogy in Case One, and optionally used i.e., loosely integrated in Case Two. Semi-structured in-depth interviews were employed to solicit student experiences of using podcasts. Access logs from the podcast server provided insight into frequency of use of podcasts, thereby helping to establish the relation between podcast use and facilitation of learning. The findings suggest that students were confident in using podcasts for academic purposes. This is despite having had to overcome some challenges not limited to institutional policies on limited Internet quota for students. The findings also suggest that use of podcasts within a constructivist learning environment afforded learners control and flexibility, reflection and self-paced learning. The paper concludes that podcasts facilitate learning when tightly coupled to a curriculum and used within constructivist learning environments.

Keywords
Podcasts, Ubiquitous technologies, Constructivism

Introduction

Ubiquitous technologies are technologies that are commonly available and accessible to most in a particular community. The ubiquitous nature of mobile devices explains why students are fairly conversant with using mobile technologies even before entering university. Evidence shows that the majority of university students own at least one or an assortment of mobile devices like mobile phones, MP3 players and iPods. For example, at the University of Cape Town (UCT) over 98 percent of students (http://www.cet.uct.ac.za/projects) own mobile phones and other mobile technologies, though the use of these devices in teaching and learning is limited. Although the range of uses of these devices is wide, predominant uses include social interaction and entertainment. This therefore provides educators the opportunity to converge social and entertainment uses of mobile devices to scaffold student learning and foster deep engagement with content. This paper exploits the fact that students can afford mobile devices (Wood, 2003), which are already intricately interwoven into various aspects of students’ lives (Traxler, 2009). The thesis of this paper is that listening to podcasts on mobile devices could cognitively scaffold learning, converging students’ social and entertainment spaces into the learning space. This paper reports on a study that exploited podcasts and ubiquitous technologies for teaching and learning in a blended postgraduate programme at a South African university.

Motivation

Van Hooft (2008) suggests that the affordances of mobile technologies enable students to be mobile, to be connected and digitally equipped all at the same time. The emphasis, when using ubiquitous technologies for educational purposes, is on how computing and mobile devices share, distribute and enhance engagement with both content and knowledgeable human agents. Thus the affordances of mobile technologies leverages classroom activity and interaction, and is therefore ideal for situating learning and contextualizing it (van Hooft, 2008).

Literature on the use of mobile devices in academia highlights a polarity of views regarding the types of devices commonly used. Some studies indicate that devices with no connectivity have not proved popular or sufficiently useful in education (Faux, McFarlane, Roche & Facer, 2006). Faux et al. (2006) however also observe that non-
connected devices such as iPods and MP3 players are used alongside connected devices such as mobile phones. We saw this an opportunity which could be used to extend learning space for students by enabling them to download podcasts onto non-connected devices (i.e., iPods, or MP3 players) for listening off-line and using connected devices (i.e., mobile phone) to engage with peers on content.

The motivation for this study was drawn from Armstrong and Franklin (2008), who argue that in cases where confidence in students’ ability to access Web 2.0 tools is found, academic staff is driving the use of Web 2.0 tools in general by innovating new practices. Armstrong and Franklin (2008) suggest that podcasts and vodcasts are used variously across the institutions surveyed in the UK, the US, the Netherlands, South Africa and Australia. This echoes Armstrong, Tucker, and Massad (2009), who argue that students easily accept integrating podcasts with curriculum content because they are already competent users of MP3 players and iPods. This means that students’ entertainment experience with mobile devices could therefore be exploited for educational purposes. However, this is not without challenges. As mobile technologies become ubiquitous and podcasting becomes more acceptable among students, the challenge lies in shifting educators’ view from seeing podcasts as a technology, to using podcasts as a teaching tool at pedagogical level. Ng’ambi (2008) stresses that listening to podcasts however does not necessarily translate into learning, adding that podcasts ought to be integrated into the curriculum.

Thus, the study reported in this paper aimed at developing a framework for integrating podcasts into the curriculum. The framework was based on empirical findings of an investigation into how postgraduate students used podcasts within a reflective learning context.

Related projects

Developments in podcasting tools have been on the increase and most recently mobile podcasting (http://www.podcastingnews.com/topics/Mobilecasting.html) has become possible. With mobile podcasting, the process of audio content creation, formatting and distribution for use on various devices is usually transparent to the user. The need for transparency is important because students traverse between social spaces and educational ones. The University of Minnesota (2006, p. 1) argues that ‘Podcasting involves a shift from e-learning to m-learning’ as it provides another way of widening student learning experiences beyond campus settings through the use of mobile devices such as laptops, mobile phones, MP3 players and iPods. The challenge for academics and learning designers is to explore ways of how to best integrate podcasting in the curriculum so as to take advantage of the affordances of technologies available to students on and off-campus.

Podcasts have been used at the University of Cape Town, South Africa, at both undergraduate and postgraduate level since 2007. In a study involving postgraduate students, Ng’ambi (2008) reports on how students whose first language was not English struggled to understand lectures during face-to-face sessions where the use of podcasts became an indispensible learning tool. Ng’ambi (2008) contends that effective implementation of podcasts into curricula, particularly in resource constrained contexts happens at two levels: the pedagogical and activity layer. Ng’ambi (2008) explains this to mean generating podcasts becomes part of the teaching strategy and entails designing reflective learning tasks whose accomplishment require listening to a podcast.

Types of Podcasts used in education

In 2007, Rüdel proposed four types of podcasts, which depended on the nature of the content delivered to students. These are: 1) traditional course content such as archives of lectures delivered face-to-face, 2) additional course content which enhances learning by providing material that is relevant to the course, 3) supplemental course content not crucial to passing examinations, and 4) podcasts containing content from students for the lecturer or other students. For purposes of this study, the first three types are classified as lecturer-generated podcasts, while the last is classified as student generated. Harris and Park (2008) contend that the early adoption phase of podcasting by universities tended to focus on podcasts as a technology or tool, implying that little or no emphasis was put into providing podcasts based on pedagogically sound principles.
The shift is now toward providing high-quality podcasts with the aim of providing learning resources which are aligned with pedagogy. Tsagkias, Larson, and de Rijke (2010) propose a podcast analysis framework they refer to as PodCred. Though the framework Tsagkias et al. (2010) propose helps podcast users assess both the quality and credibility of podcasts, it however provides no guidance on teaching with podcasts. The research by Tsagkias et al. (2010) follows the work done by several institutions in the UK on academic podcasting, which culminated in the proposition of a model by Edirisingha, Salmon and Nie (2008) for effective academic podcasting. The model sets out ten-step guidelines for use in implementing podcasting in academic settings. While the model by Edirisingha et al. (2010) served as a guiding framework for developing a podcast implementation strategy, it did not provide a pedagogical strategy for teaching with podcasts. We sought to understand patterns of use when podcasts are tightly integrated (i.e., tasks designed that require listening to podcasts) with curriculum and when loosely integrated (i.e., podcasts made available for discretionally use, not informed by a learning task). The assumption guiding the study was that by providing students with podcasts, students gained control of their own learning, were empowered to make choices on time, place and frequency of playback thereby increasing learner control. As podcasts enabled learner control and flexibility, podcasts were useful in helping to shift the focus from knowledge transmission to knowledge creation, a tenet of constructivism.

**Constructivism**

Theories of knowledge construction and acquisition emphasize the centrality of cultural and social factors in cognitive development. Constructivism is a set of concepts regarding human learning tracing its roots to eminent scholars including Dewey, Piaget and Vygotsky. Perkins (1999) argues that because constructivism is a composite of different views incorporating active, social and creative aspects of learning, different kinds of knowledge are elicited from different constructive perspectives and there is thus no single constructive approach. Constructivism positions learning as the active construction of knowledge structures through experience. This is particularly relevant to this study in that the process of making meaning from listening to podcasts is an active reflective process which requires students to bring prior knowledge to the process. Campbell (2008) quotes Merriam and Caffarella (2001), who define constructivism as “...an array of perspectives, postis that learners construct their own knowledge from their experiences. The cognitive process of making meaning is emphasized as both an individual mental activity and a social interactive interchange” (2008, p. 75). Campbell adds that Merriam and Caffarella have managed to advance “…a well articulated teaching philosophy” (2008, p. 5), with a range of application in various learning contexts. For Mayes and de Freitas (2004) constructivism conceives learning as the realization of understanding through active discovery, dialogue and collaboration. Constructivism, Mayes and de Freitas (2004) argue, is concerned with the internalization of knowledge and skills, their integration into existing structures and the effect of support on their emergence. They add that effective learning can be applied to different contexts, expressed in new ways, including the use of technologies which provide opportunity for reflection, self-paced and independent learning.

Atherton (2005) argues that the “…the learner is much more actively involved in a joint enterprise with the educator of creating (“constructing”) new meanings” (emphasis in original). Atherton adds that constructivism’s emphasis on students’ prior knowledge and understanding can benefit higher education particularly in the areas of resistance to learning and learning through reflection as constructivist assumptions are implicit in reflective practices. Within constructivist environments, the role of academics according to Atherton (2005), is to initiate discourse, with the primary objective of helping students to reach understanding. Perkins (1999, p. 11) suggests that in constructivism, “active learning is the common denominator.” This is in agreement with Hung (2001, p. 282), who points out that the different views of constructivism hold that “… learning is an active process of constructing knowledge rather than acquiring knowledge.” Hung also argues that the key concepts underlying constructivism are personal discovery, usually from first principles, the uncovering of alternative perspectives and making sense of them. These concepts are quite problematic to achieve in learning environments which assume that learning is the transmission of knowledge to students. Kanuka and Anderson (1999) identified four constructivist positions from literature, whose common themes they summarized as follows:

I. new knowledge is built upon the foundation of previous learning;
II. learning is an active rather than a passive process;
III. language is an important component of the learning process; and
IV. the learning environment should be learner-centric.
The common constructivist themes suggested by Kanuka and Anderson provide a way of viewing listening to lecturer-generated podcasts and encouraging students to generate their own podcasts as opportunities for creating new knowledge built on previous learning. It also engages students actively and places students at the centre of the learning process. Phillips (1995) provides three ways of understanding knowledge acquisition based on constructivist philosophy namely, active acquisition of knowledge and understanding; social construction of knowledge and understanding; and finally, the creation/recreation of knowledge and understanding. In other words, knowledge and understanding are actively created and recreated within particular social contexts. It therefore follows that use of educational podcasts would allow students to engage in constructing knowledge and understanding while using the same devices already used for social and entertainment purposes.

Methodology and description of case study

The study adopted an interpretive approach to investigate how students enrolled on a blended postgraduate programme in Educational Technology used podcasts for reflective learning. A blended learning approach integrated on-line and face-to-face teaching strategies, where students worked on pre-contact tasks online, then spent six full-days (from 09h00 - 16h00) in face-to-face sessions, and finally completed an individual task post-contact. The pre-contact session lasted for two to three weeks and post-contact task four weeks. Podcasts were created and made available at the end of each day during face-to-face sessions.

Alvarez (2002) contends that an interpretive approach allows researchers to view participants in a study as active knowledge constructors within their contexts. Using students’ narratives of their experiences, the researchers gained understanding of how students used podcasts and their reflective process mediated by podcasts. The postgraduate students already used e-learning in all modules. The Web 2.0 tools such as blogs, wikis, and maps were used within the institutional learning management system (LMS). The University of Cape Town uses Sakai (http://sakaiproject.org) branded as Vula. The aim of this study was to use devices available and accessible to most students, and to use a familiar e-learning platform. The researchers therefore decided to use Vula as a Podcast Server. While on campus, students could download podcasts from Vula to their mobile devices and MP3 players to listen to off-line. On-campus most students had little or no access to high broadband and downloading of podcasts off-campus was expensive. Students also subscribed to different aggregators which they used to download podcasts using Really Simple Syndication (RSS). With the use of RSS feeds, some students downloaded podcasts to mobile devices.

Students used podcasts within a reflective learning approach. The researchers investigated two cohorts of students, Case Study 1 and Case Study 2, with 16 and 18 participants respectively. The teaching strategies were the same in both cases, though the pedagogies were slightly different. In Case Study 1, podcasts were tightly coupled into pedagogy; learning tasks were designed such that students were required to listen to podcasts in order to complete the tasks. In Case Study 2, podcasts were available but tasks did not require using podcasts, making podcast use optional. In both cases, students’ podcasts (student-generated podcasts) of presentations, seminars and group report-back sessions were recorded and uploaded on to the course site, making them available for use to support reflection. Each student maintained a personal and private daily reflective blog on their learning. Lecturer-generated podcasts consisted of lecture recordings and lecturer recommended podcasts from other sources. The details of the two cases are outlined below:

Case study 1: 2008

Contact week

Number of participants: 16

Teaching strategy:
- Guest lectures
- Group tasks
- Student-led seminar
- Reflective blogs
Pedagogy
- Podcasts tightly coupled into pedagogy
- Constructive learning approach
- Lecturer-generated podcasts
- Student-generated podcasts
- Students’ daily blog reflections

**Case study 2: 2009**

Contact week

Number of participants: 18

Teaching strategy:
- Guest lectures
- Group tasks
- Student-led seminar
- Reflective blogs

Pedagogy
- Podcasts loosely coupled into pedagogy
- Constructive learning approach
- Lecturer-generated podcasts
- Student-generated podcasts
- Students’ daily blog reflections
- Podcast to accompany research paper at end of module

In addition to using podcasts provided by lecturers and those created by students to facilitate reflection, students in Case Study 2 were each required to create a 10 minute podcast as part of an assessment task to accompany a research paper. Students were expected to use software like Audacity, to create a podcast and upload it on to the course site.

According to Schmit (2007b), giving students the opportunity to create their own podcasts enables them to co-construct knowledge and engage in high-level cognitive processes. Thus student-generated podcasts are ideal for use in constructivist teaching approaches as the podcast production process facilitates critical engagement with content, which can lead to effective learning as students use the knowledge acquired in class as the foundation for subsequent learning as they put the content for their podcast together. Student-generated podcasts also provide students with the opportunity for active involvement in learning and enable students to use high-level cognitive processes as they conduct research and formulate the concepts/ideas which comprise the podcast content. (Schmit, 2007a, p. 16) argues that student-generated podcasts provide authentic artifacts which academics can use to assess student knowledge as these can be used to “observe factual and conceptual understanding in the cognitive domain.” Using podcasts in this way also helps to make learning an active process and created a more learner-centric environment.

All student-led seminars including student report-back sessions from group tasks were recorded and uploaded onto the learning management system (LMS) Vula, which was used as a Podcast Server. The rationale for distributing the podcasts via the LMS was to ensure equitable access, as all students enrolled on a course had access to all resources on the LMS. The audio was first edited using Audacity with the aim of providing podcasts of not more than thirty minutes in length for a lecture. The nature of the seminars and student report-back sessions determined the style of presentation, content organization, the frequency and timing, as well as the authors, and medium used. It was the Course Convenor’s contention that providing podcasts, in addition to other resources, such as handouts and PowerPoint Points of all presentations, would provide students the opportunity for enhanced reflection, self-paced and independent learning, all of which played a critial role in ensuring effective learning.
Data analysis

Data was gathered from two main sources, namely face-to-face interviews with students and access logs generated by Vula. Detailed interviews were conducted with eight of the eighteen students on Case Study 2. The researchers sent invitations to students to participate in the interviews to eighteen (18) students. Ten (10) students initially agreed to be interviewed but only eight were available for interviews. Interview data were analyzed using thematic analysis. Table 1 below gives a summary of the themes, and categories that emerged from interview data.

<table>
<thead>
<tr>
<th>Theme</th>
<th>Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>Critical engagement</td>
<td>Memory aid</td>
</tr>
<tr>
<td></td>
<td>Reflection</td>
</tr>
<tr>
<td>Extending the learning space</td>
<td>Traditional setting</td>
</tr>
<tr>
<td></td>
<td>Informal setting</td>
</tr>
<tr>
<td>Technical aspect</td>
<td>Bandwidth</td>
</tr>
<tr>
<td></td>
<td>Awareness</td>
</tr>
</tbody>
</table>

Table 1. Themes emerging from interview data

Interview transcripts were emailed to interviewees for verification before being analysed. The analysis involved reading through the transcripts to develop themes, and then re-reading the transcripts to identify categories specific to each theme. Transcripts and categories were analysed to identify data relating to each category. The transcripts were then coded according to categories. Access logs generated automatically by Vula were used to determine the frequency of access of podcasts. These show which podcast was accessed how many times and by whom.

Interview data

Critical engagement with content

Phillips (1995) stresses that knowledge construction and meaning making are active processes. This implies critical engagement with content. Podcast content should be designed to recruit student attention and provoke thought and be embedded in the curriculum so as to enable students to discern the academic value of using them. Using podcasts enable students to critically engage with content as they build upon previous knowledge by consolidating concepts discussed during lectures, take reflective notes and help to formulate questions for further exploration with the educator and or peers. Six of the eight students said they benefited from using podcasts to support their learning, as the comments below illustrate (unedited):

I did use it [podcast] in distance education, where podcasts were an important part of the educational programme...You had to study a video first, then the theory, and then do the test... (02MR/2)

...it’s [podcast] really useful especially when it comes to what has been said before that in a class set sometimes, there are things which will... you won’t aah really grasp for the first time...I cannot concentrate for two... my mind always wanders...when I use podcasts some of those things I can actually get hold of (05MU/2)

...if you talk about reflections...you may have very little. But now with the podcasts with you, then you can be able to replay it, actually capture what is outstanding for you... (06MU/2)

Two inter-related categories emerge here, those of using podcasts as an aid to memory and as an aid to reflection. Reflection is a post-event process of meaning making and is dependent on one’s ability to remember details of the event in order to relive an experience. Thus improving students’ ability to recall details increases the chances of effective reflection. Effective reflection is the result of critical engagement with post-event details (content) and is highlighted by how well students are able to restructure their views and integrate multiple perspectives.
Extending the learning space

Mayes and de Freitas (2004) contend that technologies which provide opportunity for reflection, self-paced learning and independent learning have a critical role to play in ensuring that learning is effective. Once downloaded, podcasts can be used in various settings, with devices of students’ choice and at students’ discretion. This implies that podcasts lend themselves well to facilitating self-paced and independent learning. Students can use podcasts in traditional academic settings but are confined to specific physical spaces or time. Podcasts can also be used to widen students’ learning space into informal settings as academic content can be used beyond campus settings, what is referred to as “time shifting.” Six of the students interviewed used podcasts to extend the learning space, though the concept of extending the learning space is specific to individual students. Making use of odd bits of time, such as the commute to and from campus and guiding further research are some ways podcasts can extend the learning space. Interview data shows that students used both portable and fixed devices to listen to podcasts, including “cell-phone,” “computer” and “laptop,” which shows that learning takes place across settings, both formal and informal:

...when I listen to the podcasts, I normally just listen on a computer. And I have listened on a cell-phone as well...you can listen whilst you are walking or you can listristhe period between... when I’m in between places is lost time (05MU/3 - 4)

...I use my laptop...can’t do away with paper, pen and paper...I jot down some of the things I think I missed and I would want to research further (06MU/3)

Traditional settings are where students “can’t do away with...pen and paper...jot down,” and “research further” is necessary. Informal settings include “in between places” where podcasts could be used for self-paced and independent learning. This echoes Armstrong and Franklin (2008) who argue that the nature of learning boundaries are altered by using podcasts. This is in addition to enabling “new flexible virtual spaces without walls or time constraints” (Armstrong & Franklin, 2008, p. 22).

Technical aspect

This theme is concerned with technical execution as proposed by Tsagkias, Larson & de Rijke (2010) in their framework. It is centred on issues relating to production, packaging and distribution of content. Students’ highlighted issues relating to file size “the podcast files are large,” and bandwidth “worried about how much.” In the South African context, broadband Internet access and bandwidth is a major challenge to the educational use of podcasts. As students move away from campus, they have limited or no access to broadband Internet. While podcasts can be downloaded using dial up Internet, the process is slow and costly. This makes downloading podcasts time consuming, which by extension means that time-constrained students are unlikely to use dial up Internet to get podcasts. Though this is not the case, students assume downloading podcasts or vodcasts (video podcasts) uses up their Internet quota and they therefore would rather use it for other purposes such as ‘research for my assignment’:

Unfortunately you find that the files, the podcast files are large. I would want to have them on my phone and then listen even on the bus so given the opportunity to have the other nice devices I would listen almost anywhere. (05MU/3)

It also takes too long to download. I was quite excited about using the podcasts...it is frustrating to wait for everything to download. I was also worried about how much bandwidth it was using since I still needed to do a lot of research for my assignment. (07FE/1 - 2)

Awareness of podcasts and the use of RSS feeds is another theme that emerged from the data. All students interviewed admit to either being familiar with podcasting or using aggregators, such as iTunes and newsfeeds for non-academic purposes. Data indicates that students are aware of RSS feeds—“do my downloads through iTunes,” and podcasting “seeing it on the net,” as well as the possibilities it offers in terms of automatic acquisition of content. Podcast access logs show that two of the interviewees tried using podcasts but gave up, while two were top users of podcasts provided on the course. Students often do not think of learning resources as content and may thus not be taking full advantage of academic podcasting, including the use of RSS feeds:
...I do my downloads through iTunes...I use it more for news and other issues. (02MR/2)

...I guess it’s a matter of seeing it on the net…but you never think about it…or bothered much about it…I actually heard about it for the first time officially in that course. (05MU/1)

Most postgraduate students commute to campus and hence have no access to broadband Internet access at home and are in most cases, unable to pay Internet service providers, as these services require signing contracts with the service providers. They are therefore unable to subscribe to RSS feeds of academic content.

**Data from access logs**

Access logs were useful in comparing patterns of access to learning resources over time. Access logs for both case studies were compared to highlight variations over time. All students enrolled on and all lecturers on teaching on the programme had access to the podcasts. However access logs analysed did not include the downloading frequency of podcasts by lecturers. It is important to note that though downloading resources from Vula did not affect monthly Internet quota, many students assumed this was the case, which may have negatively affected podcast use.

Data from the two case studies is presented in a frequency table (see Figure 1 and Table 2). The frequency tables compared the number and percentage of podcasts downloaded for both case studies in terms of student- and lecturer generated podcasts. Table 2 presents a comparison of access patterns for the two case studies. Data from the access logs were arranged into categories in order to compare the distribution of access across the two cases. Since the data set ran up to 69 and 60 for Case Study 1 and 2 respectively, the data was broken into segments of ten, giving a total of seven categories.

![Figure 1. Comparison of the two case studies](image)

<table>
<thead>
<tr>
<th>Class interval</th>
<th>Case Study 1</th>
<th>Case Study 2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Student-Generated</td>
<td>Lecturer-Generated</td>
</tr>
<tr>
<td>0-10</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>11-20</td>
<td>24</td>
<td>2</td>
</tr>
<tr>
<td>21-30</td>
<td>15</td>
<td>8</td>
</tr>
<tr>
<td>31-40</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>41-50</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>51-60</td>
<td>0</td>
<td>5</td>
</tr>
<tr>
<td>61-70</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Total</td>
<td>45</td>
<td>24</td>
</tr>
<tr>
<td>Access Ratio</td>
<td>65%</td>
<td>35%</td>
</tr>
</tbody>
</table>
The data illustrated that frequency of access across the various class intervals, of podcasts was not equitably distributed during both years. This suggested a ranking trend based on the frequency of access. The data also revealed that there was better distribution of access in Case Study 1 compared to Case Study 2, as shown in the Figure 2 below.

![Figure 2. Access patterns of podcasts for both case studies](image)

In Case Study 1, podcasts accessed the most fell in the 11-21 and 21-30 class intervals, which accounted for 38% and 33% of total podcasts. In Case Study 2, the most accessed podcasts accessed fell in the 0-10 and 11-21 class intervals, which accounted for 53% and 35% of total podcasts. This translated into 71% and 88% for the class intervals with podcasts accessed the most for Case Study 1 and 2 respectively. Overall, student-generated podcasts were downloaded the most in Case Study 1, while lecturer podcasts were used the most in Case Study 2. One of the tasks given to Case Study 1 required students to cite at least three other students in discussing how peers’ reflections affected theirs. They had to listen to other student-generated podcasts in order to complete the task, which was not the Case Study 2.

<table>
<thead>
<tr>
<th></th>
<th>Total number of podcast users</th>
<th>Total number of students</th>
<th>Total number of podcasts</th>
<th>Total RSS feed downloads</th>
<th>Total number of downloads</th>
</tr>
</thead>
<tbody>
<tr>
<td>Case Study 1</td>
<td>23</td>
<td>16</td>
<td>69</td>
<td>417</td>
<td>1831</td>
</tr>
<tr>
<td>Case Study 2</td>
<td>21</td>
<td>18</td>
<td>60</td>
<td>245</td>
<td>673</td>
</tr>
</tbody>
</table>

Both lecturers and students had access to the course site and all resources, including podcasts. The total number of podcast users include seven lecturers and one research assistant in Case Study 1 and four lecturers and one research assistant in Case Study 2.

In both case studies, two lecturers on the postgraduate course did not teach on the course. It is assumed that these lecturers expressed interest in how podcasts were used on the courses and were added to the course sites by the course convener. In additional, some students chose to download podcasts anonymously using RSS feeds. These figures stand at 417 and 245 in Case Study 1 and 2 respectively. RSS feeds make podcasts available to students automatically. The fact that few students on the course accessed podcasts via RSS feed is indicative of the possible digital divide, in particular the fact that access to internet connectivity off campus was uneven. It could also suggest that students preferred to access podcasts from the course site as they could look at other resources while downloading podcasts.

**Discussion**

Analysis of access patterns suggests that podcasts provided different learning opportunities to students on the two case studies provided. In Case Study 1, podcasts were tightly coupled with pedagogy and this led to high usage of
podcasts. In Case Study 2, although podcasts were not tightly coupled with pedagogy, it modelled the effective use of podcasts to students in supporting teaching and learning. To the extent that students were required to prepare a podcast to support their project essay, students were provided with learning opportunities to reflect on the task at hand, and to construct new knowledge through active learning. The use of podcasts in both cases was therefore in alignment with constructivist principles espoused by Mayes and de Fretas (2004), Atherton (2005), Perkins (1999) and Kanuka and Anderson (1999). Some of the educational benefits accrued from using podcasts include facilitating the meaning making process, directing learning through facilitating question formulation, facilitating critical engagement with content and effective communication of ideas through students’ reflection on peer’s podcasts. Podcasts also augmented consultation space by affording deep engagement in question-based consultations that was often a setback of traditional face-to-face sessions. Lecturers can structure podcast content, including lecture archives to give students the opportunity to make comprehensive notes while they listen, formulate questions for exploration with lecturers and peers, thus directing further learning. Table 4 below summarises the benefits observed from the case studies:

<table>
<thead>
<tr>
<th>Teaching Strategy (Facilitate reflective learning)</th>
<th>Pedagogy (Podcasts)</th>
<th>Benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lecturer-generated podcasts</td>
<td>Tightly coupled with pedagogy</td>
<td>Scaffold meaning-making process</td>
</tr>
<tr>
<td>Design learning tasks to involve students in knowledge production (use Student-generated podcasts)</td>
<td>Constructive learning approach</td>
<td>Formulate questions to direct further learning</td>
</tr>
<tr>
<td></td>
<td>Build on existing competencies and skills</td>
<td>Facilitate critical engagement with content (i.e., provide cues to enable purposeful listening to podcasts)</td>
</tr>
<tr>
<td></td>
<td>Encourage collaborative and active learning</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Augment presentation with reflection</td>
<td></td>
</tr>
</tbody>
</table>

Since only students enrolled on the course had access to resources, including podcasts, it can be inferred that frequently accessed podcasts could be indicative of a topic students had difficulty understanding hence the need to listen to it again, or a topic that generated interest. Students may want to share or recommend such podcasts to others. This suggests that educational podcasts would be shared among students like they already share music (e.g., using Bluetooth). Tsagkias et al. (2010) observe that many students own mobile devices with sufficient capacity to store and playback music, which suggests readiness for using podcasts in education on the student side. This could be achieved through mobile devices leveraging institutionally provided computers. Thus, this paper has focused on the readiness of the educators and through the case studies, illustrated two strategies of integrating podcasts as a teaching and learning tool.

**Conclusion**

This paper has illustrated podcasts’ potential to transform student’s social and entertainment spaces into learning spaces. It has shown that such transformative change requires tight coupling of podcasts into pedagogy. The study has demonstrated that students accessed and used podcasts more when integrated with pedagogy, as with Case Study 1. Both case studies indicate the need to take into consideration when embedding technologies in educational programmes and make the following recommendation:

I. Effective educational use of podcasts requires that educators integrate podcasts in the task design. This has illustrated two approaches—requiring students to perform a reflective task where podcasts play a scaffolding role; or modelling the creation and use of podcasts with the view to asking students to create their own podcasts.

II. Ensure that technologies required to engage with a podcasting task are ubiquitous, reducing lack of access to technology which allows students to focus on the required task. This paper has illustrated how the LMS served as a podcast server, and students used devices they already owned and used for social and entertainment purposes.
III. Exploit students existing competencies and create learning environments where students teach and learn from one another. In this paper student drew on their existing competencies of using devices (MP3 players and iPods) to download, playback and share music, and applied same skills to using podcasts. The use of RSS feeds by students is an example of transferable skills.

IV. Teaching strategies are informed by assumptions about learning that educators hold. These assumptions/theories ought to be made explicit in order for the educator to stay focused. In this paper, podcasts were used to mediate reflective learning in a constructivist learning paradigm. This influenced the task designs, both in integration and use of podcasts.

The researchers conclude that podcasts can be used as learning resources for facilitating student learning. The extent to which this is done is dependent on environmental and pedagogical factors. Using podcasts within a constructivist paradigm encourages scholarly knowledge construction as students are given the opportunity to engage with content critically. We also conclude that the value of using ubiquitous tools in education is two-fold; namely:
1) Cost-effectiveness as there are no additional costs in acquiring and training students to use new tools, and
2) Ensuring more equitable access to content and by extension, widening students’ learning space.

Based on students’ preference of listening to podcasts on personal computers and laptops, and multiple download of specific podcasts by the same users, we conclude that student ownership of mobile devices able to play podcasts is yet to support mobile podcasting as the primary means of academic podcasting.

References


Evaluation of Teaching the IS-LM Model through a Simulation Program

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ABSTRACT

The IS-LM model is a basic tool used in the teaching of short-term macroeconomics. Teaching is essentially done through the use of graphs. However, the way these graphs are traditionally taught does not allow the learner to easily visualise changes in the curves. The IS-LM simulation program overcomes difficulties encountered in understanding the curves used in the model because, through it, the students can visualise the changes in these curves when the model’s parameter values are modified. The IS-LM simulation program is presented and the effectiveness of its application to a group of macroeconomics students at the University of Seville during the 2009/10 academic year is evaluated. Analysis of variance (ANOVA) of all students’ scores and some complementary statistical tests were applied, distinguishing between students who used the simulator and those who did not. The average score obtained by the former in a model comprehension test was significantly higher than that of the latter.

Keywords

Computer simulation, IS-LM model, Learning technology, Macroeconomics teaching

Introduction

The IS-LM model is a common and essential tool used in the teaching of macroeconomics. Despite criticisms of this model ever since the 1970s, it has persisted and survived through several modifications and the incorporation of new elements (Becker, 2000). The strange endurance of the model, as Colander (2004) describes it, is associated with its pedagogical use in intermediate macroeconomics courses and business schools. The IS-LM model is a framework which provides students with insights into some of the workings of macroeconomics and offers teachers the opportunity to show students the way in which economists think.

One benefit of learning the IS-LM model is that it provides a useful instrument to examine the determinants of the effectiveness of monetary and fiscal policies in generating a short-term change in the balance of the gross domestic product (GDP). This effectiveness may be analysed by using the tools of multivariate calculus, but these tools are too complicated for most students of intermediate-level macroeconomics. However, through the use of graphic techniques the students are much more easily able to understand the IS-LM framework, as Revier (2000) stated. The IS-LM model is then translated into a set of concatenated graphs which are representative of the model developed by Hicks (1937). As explained in Section 2, through the graphs it is possible to visualise the effects of economic policies. Therefore, graphical comprehension is fundamental to understanding economic interaction.

However, the use of traditional or static graphs to explain economic issues does not always benefit the students. As Cohn et al. (2001) stated: “If the graphs are relatively complicated and students have little time to absorb them, review the material, and have opportunities to ask questions about them, the use of graphs may not be helpful or may even be counterproductive.” In fact, in a test given to students of Macroeconomics I at the Business Administration School of the University of Seville in 2008, it was observed that the students had difficulties in understanding changes in the slopes of the curves (Pablo-Romero et al., 2009). The difficulties in the comprehension of the mathematical functions and their graphical representation identified in the university context are not an isolated phenomenon; many research studies—mostly based on the contributions by Duval (1993, 2006) and Arcavi (2003)—illustrate these difficulties. For this reason, an improvement in the teaching of the graphs could contribute to a better understanding of the IS-LM model and, consequently, of macroeconomic relations.

The equipment used in teaching the graphs of the IS-LM model has traditionally been the black/whiteboard or, more recently, Power Point presentations. Such equipment/technology has also been traditionally used to teach economic...
issues in undergraduate economics courses, although there is a noticeable shift towards the use of other teaching techniques (Watts & Becker, 2008). In Spain, the adaptation of the principles of the Higher Education European Space established in the Bologna Declaration (1988) is also promoting a revision of teaching methods in economics. The incorporation of the ECTS (European Credit Transfer System) credits as the measurement unit of the students’ work aims to promote the student’s involvement in the learning process beyond passive class attendance and the passing of the final test. It also means providing the students with learning material which should allow them to actively participate in learning the subject.

Traditional forms of graphical representations can be expanded thanks to the availability of new information technologies. In this way, as stated in Chen and Howard (2010), technology can help in the scientific learning process because of its potential to support activities such as visualization, meaningful thinking, problem solving and reflection. However, these graphs should satisfy certain requirements to help student learning, such as allowing the student to interact with them (Betrancourt, 2005). Also, the graphics must meet certain rules or principles, as indicated by Tuft (2001, 2006), Sweller (2005) and Mayer (2005a, 2005b), among others.

Following these principles, a software application has been developed which allows the students to interact with the model, offering the possibility of doing as many different exercises as there are different economic situations. Within the classification of learning objects considered by Churchill (2007), this application can be included within the group "contextual representations", in the sense that a realistic scenario can be explored for economic-specific policy.

In the university teaching context, the use of simulation programs is expanding in many areas of knowledge. While the use of computer- and non-computer-based simulations and games is undergoing significant levels of growth in education (Lean et al., 2006), few studies however have analysed their impact on students’ levels of achievement (Jonassen, 2003; Kim & Reeves, 2007). In the context of economics teaching, different simulation programs have also been implemented, although in most cases, these programs are limited to quantitative methods and IT skills training (Hobbs & Judge, 1992). Among those who discuss different computer simulations used in teaching economics, Bolton (2005), Santos (2002), and Schmidt (2003) are worth mentioning. Porter et al. (2004) reviewed the use of simulation programs in this area and stated that the creators of these simulation programs consider that “simulation motivates students to learn, makes economics relevant and improves critical thinking.”

Nevertheless, and despite the fact that the use of these simulation programs has grown continuously over the last 10 to 15 years (Schmidt, 2003), few controlled studies have been made of the effectiveness of simulations in this area. Porter et al. (2004) consider that the literature describing the impact of the use of simulations on learning remains very thin in the field of economics, particularly when we consider the small number of studies within a specific category. Therefore, as stated in Grimes and Wille (1990), it is important to determine the effectiveness of the use of simulations on student learning. As stated in Clark et al. (2009), researchers should take a pragmatic approach in applying findings from research done in the past, or in other contexts of their own situations, audiences, and settings. Therefore, more analyses of the effectiveness of the use of simulations on student learning in the field of economics may be convenient. In this sense, the introduction of e-learning methods and tools should be evaluated by controlled experiments and rigorous statistical analysis of the experimental data.

This paper contributes to the literature in relation to the impact of simulation use on student learning in the field of economics. The aim of this paper was thus to evaluate, using rigorous statistical analysis, if macroeconomics students at the Business Administration School of the University of Seville benefited from use of the IS-LM simulator as a learning tool to perform this evaluation, we carried out an analysis of variance of the scores obtained by two groups of students (one group taught using the simulator and the other in a traditional, classroom-based manner) in which the exam question was specifically relevant to theory that could be explained by invoking the IS-LM model.

In the second section of the paper, we discuss the operation of the simulation program and explain the learning process that students underwent. In the third section, we analyze the scores obtained by students who were taught to use the IS-LM model simulation program and who employed it to carry out their individual exercises, and compare them to the scores obtained by the students who did not have access to the program. Analysis of variance (ANOVA) of those scores and some complementary statistical tests using the R statistical program were applied. This is followed by a discussion section and finally we present the main conclusions.
The IS-LM simulation program

With the aim to facilitate the comprehension of the mathematical-graphical relations of the IS-LM model by students, an interactive simulation program was created in C++ language for the Windows operating system.

Essential of the IS-LM model

The IS-LM model shows the interaction between the real (IS curve) and monetary (LM curve) markets in the short term. The real market determines the level of income while the money market determines the interest rate. Both markets interact and influence each other. The income level will determine the demand for money and therefore the interest rate in the monetary market, while the interest rate influences investment demand and therefore income in the real market.

The IS curve shows the situation of balance between aggregate demand ($D_A$) and supply of goods and services ($Y$) in the short term for different values of income and interest rate. Graphically it is derived directly from income-expenditure model, which relates the aggregate demand with the supply (graph located above in Figure 1). The $D_A$ and the IS curve are specified as follows:

$$D_A = \bar{A} + c(1-t)Y - bi, \text{ with } \bar{A} = \bar{C} + c\bar{TR} + \bar{I} + \bar{G}$$

where

c = marginal propensity to consume
\( t \) = tax rate
\( b \) = sensitivity of the investment to interest rate variations
\( i \) = interest rate
\( \bar{C}, \bar{TR}, \bar{I}, \bar{G} \) = Autonomous consumption, state transfers, autonomous investment and public expenditure

The IS curve:

$$Y = \frac{1}{1-c(1-t)}(\bar{A} - bi)$$

The LM curve shows the situation of balance between supply and demand for money in the money market. Graphically it is obtained from the balance between money supply and money demand (graph located at the bottom left in Figure 1). The function of the real money supply is:

$$\frac{M}{P}$$

where

\( M \) = nominal money
\( P \) = price level

The function governing the demand for money is: $L = kY - hi$

where:
\( k \) = sensitivity of the demand for money to income variations
\( h \) = sensitivity of the demand for money to interest rate variations

The LM curve:

$$i = \frac{1}{h} \left( kY - \frac{M}{P} \right)$$

The point at which the IS and LM cross shows the position of simultaneous equilibrium in both markets (graph located at the bottom right in Figure 1). This balance may be altered by variables other than interest rate that cause movements of the curves. The changes in effective demand (consumption, investment, government spending or the foreign sector) cause shifts in the IS curve. Moreover, changes in money supply, in the general level of prices and in demand for money cause shifts in the LM curve. Thus, economic policies affecting effective demand and / or the
money market affect the equilibrium. However, the new balance is not obtained immediately since the two markets (the real and monetary) interact with each other. Thus, a final equilibrium is reached after the two markets have undergone a process of adjustment that highlights the relationship that exists between them.

Therefore, the IS-LM model provides a useful instrument to examine the determinants of the effectiveness of monetary and fiscal policies in the short-term. Through the use of simple graphic techniques with no more than paper and pencil, it is able to understand the economic relations and their equilibriums in the short term.

![Initial screen of the IS-LM](Image)

**Figure 1. Initial screen of the IS-LM**

**Components**

This computer program has two basic components. The first is the set of concatenated graphs which are representative of the model developed by Hicks (1937). The income-expenditure model (graph located above in Figure 1), the balance in the money market (graph located at the bottom left in Figure 1) and the IS-LM model (graph located at the bottom right in Figure 1). Visualization of single graphs at a time is also possible, following the principle of redundancy (Sweller, 2005), by clicking the appropriate button located at the top of the screen (Figure 1).

The second component of the computer program is a set of boxes on the left part of the screen which contain the values that may be taken by the variables \((i, i, c, \text{PMIGTR}, I, G, M, P)\), defining the functions graphically represented and their different parameters \((b, k, h)\). A change in the value of some of these economic variables will alter the position and/or the slope of the linear functions represented. Following Mayer (2005b), the signalling and temporal contiguity principles have been applied, highlighting the curve which is transformed when a parameter is modified, indicating its movement and ending position.

Also as described by Mayer (2005b), the spatial contiguity principle (data, their drivers and graphics are close to each other and visual cues linking the equilibrium of the graphs are added) and the coherence principle (only the formulas, variables and graphics needed have been included in the simulator window, with anything that might distract the student hidden from view) have been applied. Even though multimedia learning principles state that people learn more deeply from words and pictures than from words alone (Mayer, 2005a), it is important that not too much information is added to the graphs. Therefore, only graphs and variables are shown without explanatory text. Also, maximizing data-ink and erasing principle indicated by Tufte (2001) has been applied. Therefore graphics have not grid.
Program operation and student learning processes

The simulation program starts from an initial equilibrium shown on the first screen. The functions represented on this screen respond to pre-selected values of the different economic variables which define the IS-LM model and are specified on the upper left part of the screen (Figure 1).

Using the information on this screen, the students will be able to do the set exercises. They may, for instance, analyse the effect of an expansive monetary policy. The student increases \( M \), which rises for example from 202 to 407. A series of changes in the curves will follow and students must interpret economically these changes and the market imbalances. First, because prices remain fixed, \( \frac{M}{P} \) increases and the \( \frac{M}{P} \) and LM curves move to the right. The student will notice that because the previous curves are now thinner (leftmost image of Figure 2). Also, the student will see that markets are not simultaneously in equilibrium. The new cutoff point between the IS curve and the new LM curve occurs at an interest rate which is inconsistent with equilibrium in the money market and an income level that does not correspond to the one shown in the upper graph of the leftmost image of Figure 2, i.e., equilibrium in the goods market. This can be easily observed because the lines linking the three graphs do not match. As the above image has not been modified, the student learns that following an increase in the amount of money, an imbalance in the money market occurs that affects the overall balance of system.

Now the student needs to find a way to enable the money market to re-establish its equilibrium. Before making any further change in the variables of the model, the student can erase the thin lines by clicking the DA, IS, LM, L and MP buttons in the menu at the top of the screen. If these lines are deleted, the student may more easily see the effects of new changes. Once the student reduces the interest rate by an appropriate amount, the investment expenditure will increase, and the student will see the upward movement of the aggregate demand as reflected on the upper right part of the third screen. The level of income will increase and reach 271.98 units. Also he will see, in the graphic located on the lower left, how this growth in production raises the demand for money, moving the curve to the right until the equilibrium in the money market is again achieved. All markets will again be in balance. This situation is shown in the rightmost image of Figure 2. The student will have learned that an expansionary monetary policy leads to higher production and a decrease in the rate of interest. Also, the student will have learned the economic mechanism through which this occurs. To facilitate this learning by stages, students can also view single graphs at a time. Thus, the student can learn direct effects that occur in each market in response to changes in certain variables. This learning will help the student to better understand how events happen throughout the process of economic adjustment.
Through the simulation program the student can observe in a similar way the effects of a change in fiscal policy by modifying $G$, $TR$ and/or $t$. The student will be able to see as well what the effects are on the equilibrium of changes in the variables which define the characteristics of the market, such as the marginal propensity to consume, the sensitivity of the investment to interest rate variations, autonomous consumption or autonomous investment.

Likewise, the simulation program allows the student to analyse the effects of monetary and fiscal policies under special circumstances. For instance, the student may analyse a special case in which the demand for money is sparingly sensitive to the interest rate. This situation should be reflected by the student by assigning a value of 1 to the parameter $h$. By doing this, the student will find a screen similar to that shown in Figure 3. The student can easily observe that the money demand curve and the LM curve are vertical. Once the situation is known, the student is ready to analyze these effects using the IS-LM simulator.

The student's learning process is then performed over several stages. The teacher presents an economically realistic case, similar to that proposed to the students who do not use the simulator, which is solved in stages by the student. At each stage, the graphics are modified automatically by the program once the student makes a change of variables. The modification of the graphics allows the student to identify what has happened, and the imbalances that have arisen. This allows the student to identify what would happen in a real economy. This leads the student to make new changes in the variables, resulting in new graphs which can also be explained by observing what it seen. After several modifications, the student will come to a screen where all the graphics are balanced. The case has been resolved and the student can easily see the final solution and can understand what has happened in the economy. However, as the process has been addressed in stages, the student will also have learned the process of market adjustment that has taken place.

The possibilities of the simulation program are as many as the teacher and the student can imagine, and it is possible to combine more than one policy or change at a time. For this reason, the simulation program is a very helpful tool for the student to work autonomously. In addition, it allows the students to do individual and personalised tasks or exercises, thus avoiding the possibility of copying their results from other students, and not doing the practice on their own. This option can generate significant academic benefits.

![Figure 3. Money demand that is insensitive to interest rate](image)
**Basic for evaluation of simulation program IS-LM**

At the University of Seville, the teaching of macroeconomics within Business Administration Studies is divided into two courses. The first one (Macroeconomics I) analyses National Accounting in the short term. The second course (Macroeconomics II) refers to medium- and long-term analyses. Teaching in the first course is organised in traditional lectures and tasks or exercises which the students must do individually. Some of these exercises aim to facilitate the learning and understanding of the functioning of the IS-LM model.

To test the usefulness of the IS-LM simulator for teaching and learning, it has been conducted an evaluation of it, by comparing the knowledge and skills learned by students which have used the simulator and those who did not. It is considered that students which use the simulator are able to better understand the model performance, as they have the advantage of much faster exploration of causes and effects and the opportunity to do thus many more case studies and to play around with the model, and not to just copy the studies from fellow students. Also they have the advantage of do not to depend on the teacher explanations, so much.

With this aim, during the 2009-2010 academic years, the teaching method was modified for one group of students. The teacher in this group taught the IS-LM model through the above described simulation program. In addition, the students used the simulation program to perform different tasks on the IS-LM model. The students selected for this test were those registered in Group 3 of the subject, with this choice of the group made randomly. Theoretically, therefore, this group of students had no differentiating characteristics from the rest of groups in terms of their abilities or past performance. However, it must be said that students enroll in groups according to what is most convenient for them, so this may occasionally cause differences in the level between them. This circumstance is taken into account in the analysis.

To check whether the hypothesis is true, at the end of the course, all students took the same examination in which one question referred to the IS-LM model. Specifically, we asked students to compare the effects of an expansionary monetary policy and show the transmission mechanism when the economy has different sensitivities of investment depending on interest rates, in the short term. To do this, they must use the IS-LM model. However, they must not only draw the curves and demonstrate how these changed in the situations described, but also associate these changes to the behavior of the economy, and explain them in the order they occur in reality. Thus, the score obtained on this question assesses the degree of student learning and understanding of the IS-LM model, and therefore their understanding of the behavior of the economy to economic policies in different situations. And lets compare if there are significant differences between the scores of those who used the simulator and those who did not and thus if there are significant differences between the learning of them. To make this comparison between the scores of the students, it has been used an analysis of variance (ANOVA). Thus, from the analysis of the scores obtained by the students on that particular question, we assessed then the advantage of using an IS-LM simulation program in class.

With this aim in mind, the student sample (which includes all students who took the exam) was divided into three subgroups: those students who used the simulation program (S), those who attended the course but did not have access to the simulation program (A) and, finally, those who neither came to class nor did the assigned tasks (N) but, nevertheless, took the examination. Some of these students (N) attended classes in the previous year, so it was decided to include them in the study also, but as a separate group. The total sample included 324 students, of which 45 used the simulation program, 221 came to class and did their tasks but never used the simulation program, and 58 that did not attend the course regularly in that academic year and did not do the individual exercises either. The scores ranged from 0 to 10, 10 being the highest grade.

**Results**

Table 1 summarizes the main statistical results of the three groups. It may be observed that the higher means were obtained by group S (5.2), followed by group A (3.21) and finally group N (2.06). The scores in the first and third quartiles also show important differences between groups.

Histograms of the scores obtained in the answer to the question on the IS-LM model were elaborated for each group of students (shown in Figure 4). The scores of the students in group S have a more uniform distribution and their lower scores are not the most frequent ones. Groups A and N show greater frequencies of their lower scores.
However, group A presents a better score distribution in its histogram than group N, because even if lower scores are the most frequent ones, the proportion of students with higher scores is greater than in group N.

Table 1. Summary statistics. IS-LM question by groups.

<table>
<thead>
<tr>
<th></th>
<th>GROUP S</th>
<th>GROUP A</th>
<th>GROUP N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>1st Quartile</td>
<td>3.0</td>
<td>1.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Median</td>
<td>5.0</td>
<td>2.0</td>
<td>1.0</td>
</tr>
<tr>
<td>Mean</td>
<td>5.2</td>
<td>3.21</td>
<td>2.06</td>
</tr>
<tr>
<td>3rd Quartile</td>
<td>7.0</td>
<td>6.0</td>
<td>3.0</td>
</tr>
<tr>
<td>Maximum</td>
<td>9.0</td>
<td>9.0</td>
<td>9.0</td>
</tr>
<tr>
<td>Observations</td>
<td>45</td>
<td>221</td>
<td>58</td>
</tr>
</tbody>
</table>

Figure 4. Histograms of scores obtained on the IS-LM question

In order to contrast these results, a variance analysis (ANOVA) has been done which allows us to study the effect of the use of the IS-LM simulation program on the scores obtained by checking for the equality of the means of the three analysed populations. The rejection of the null hypothesis of the equality of the means implies that the teaching method and attendance in class affect the obtained scores. In order for the results of the ANOVA analysis to be robust, the sample needs to be normal and homoscedastic. The Shapiro-Wilk normality test and various variance homogeneity tests have also been done in order to check those conditions. Given that the null normality hypothesis is rejected, the data is transformed to mitigate the problem through a Box-Cox potency transformation (with the parameter of 0.28).

The transformation of the data improves normality, although it would still be possible to reject the data normality hypothesis. Nevertheless, the robustness of the ANOVA analysis is high even if data normality is not fully achieved but homoscedasticity is. The homoscedasticity test values of the transformed sample are shown in Table 2. Neither of these tests allows us to reject the null variance homogeneity hypothesis in the transformed sample. Thus, the ANOVA results can be considered quite robust.

Table 2. Homoscedasticity test and ANOVA test (score on the IS-LM question)

<table>
<thead>
<tr>
<th></th>
<th>Statistics</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bartlett test</td>
<td>0.90 (K-squares)</td>
<td>0.637</td>
</tr>
<tr>
<td>Levene’s test</td>
<td>1.80 (F value)</td>
<td>0.166</td>
</tr>
<tr>
<td>Fligner-Killeen test</td>
<td>3.04 (med chi-squared )</td>
<td>0.218</td>
</tr>
<tr>
<td>ANOVA</td>
<td>16.77 (F value)</td>
<td>1.174</td>
</tr>
</tbody>
</table>
Considering that the \( F \)-value of the ANOVA analysis is 16.778, with a \( p \)-value of 1.174, the hypothesis of the equality of means is rejected, meaning that the differences between the means by group are significant.

However, the ANOVA analysis only allows us to state that belonging to one group or another has an influence on the score obtained but it does not allow us to link the difference in the means with any group in particular. In order to determine between which groups the difference in the means is significant, a Tukey multi-comparison test is done. The results of the test are reproduced in Table 3.

The results indicate that the differences in the means are significant between the three groups. The mean of group S is significantly higher than the means of groups A and N; the mean of group A is significantly higher than the mean of group N. This shows the advantage of using a simulation program in the teaching-learning process, not only because the students came to class and did their tasks, but because of the use of the simulation program itself.

Due to the weakness of the assumption of normality, in order to provide greater robustness to the results obtained, a non-parametric Kruskal-Wallis rank sum test has been applied to the original data. The Kruskal-Wallis chi-squared statistic equals 30.6762 (\( p \)-value = 2.181) and therefore the null hypothesis of the equality of means is once again rejected, supporting our previous conclusions.

The previous results might be attributed to the groups’ own characteristics rather than to the use of the simulation program or to attendance in class and task accomplishment. In other words, they might be related to a difference in the capacities of the students in each group. In order to find out if this is true, the same comparative study was made on the average scores obtained by each group of students on the examination question which was not related at all to the knowledge or comprehension of the IS-LM model. In this case, the question was a theoretical-practical one. All the students had the same material available to allow them to answer this question successfully.

Table 4 summarises the main statistical results of the scores obtained on this question by the three groups. There are no relevant differences between the means and score distributions for the groups are more alike.

Due to the fact that the hypothesis of data normality is rejected, we work on transformed data. On the other hand, given that the hypothesis of the sample’s homoscedasticity cannot be rejected, the ANOVA results may be considered robust enough. In this case, the \( F \)-value of the ANOVA analysis equals 1.073. Therefore, the hypothesis of the equality of means between the groups cannot be rejected. In addition, by applying the non-parametric Kruskal-Wallis rank sum test to the original data, the Kruskal-Wallis chi-squared statistic shows a value equal to 2.51 with a \( p \)-value equal to 0.285 that again does not allow us to reject the hypothesis of the equality of means. We can thus conclude that the average scores obtained on the theoretical question do not diverge between the different groups. This means that the groups of students are homogeneous and their particular characteristics do not affect the conclusions drawn from the previous analysis.
Thus, we can confirm the advantages of using the IS-LM simulation program for a better learning and comprehension of the IS-LM model. Therefore, the use of this simulation program in class – and its availability to the students to work on it – facilitates the teaching, learning and understanding of the IS-LM model and, through it, of the functioning of economic relations and the effects of fiscal and monetary policies in the short term.

Discussion

To understand macroeconomic relationships, it is necessary to make an abstraction and simplification of complex economic relations that occur between economic agents. These relationships are often portrayed as causal processes, which can often best be explained by making use of graphics given that students learn these relationships in a more intuitive manner by using them. As stated in Mayer (2005a), we learn best by using words and pictures than from words alone. However, as Cohn et al. (2001) stated, the use of traditional or static graphs to explain economic issues does not always benefit the students. A graph in itself does not improve the understanding of a subject; rather, it is necessary that students learn how to formulate these graphs, and how they vary when the circumstances are different. In this sense, it is necessary to include controls which allow students to interact with the graphs because, as indicated by the animation and interactive principles in multimedia learning (Betrancourt, 2005), the static display of formulas, data and curves is not sufficient for the proper assimilation of training. In the field of macroeconomics, these controls, which allow the graphics and therefore the market balances to be changed are particularly important because the cause and effect relationships are made easily visible. This ensures that the student can understand and assimilate these relationships.

Often in the field of macroeconomics, the graphs which define markets are not isolated from other markets and therefore from other graphics. Thus, simulators should allow not only that the effects of actions are displayed in all markets, but also that the student can assimilate these effects step by step. Therefore, according to Sweller (2005), it is appropriate that the programs enable the student to see the effects on just one chart initially, and then on all graphics at once when this change is assimilated.

In this sense, the evaluation of the effectiveness of the IS-LM simulator has been very positive. This can be associated to the fact that the principles outlined above have been taken into account for its construction. It therefore seems appropriate to relate this experience to other areas of teaching of economic relations, particularly when these involve processes of cause and effect. While the results of such studies are not always transferable, as stated in Clark et al. (2009), it is necessary to accompany the use of these simulators in teaching with objective analyses for measuring their effectiveness.

Nevertheless, the advantage of using this simulation program may be due not to the program itself, but the fact that the availability of this program allows students to carry out more practical work, since the completion of each practice requires less time, and also allows viewing of each practice in stages, generating a greater understanding of the dynamics behind each particular case. In that sense, as Thompson (1999) pointed, the potential of computer mediation to foster knowledge depends less on what learners use, than on how they use it. Thus, maybe the advantage of using this program is to provide students with a tool that allows them to perform more practical work in a more autonomous way. In this sense, it seems appropriate to conduct further analysis to look for causes behind the success of this study.

Conclusions

The IS-LM model remains a useful tool for teaching and learning short-term economic relations in intermediate macroeconomics courses. While the graphical methods underlying this model improve its understanding, students sometimes nonetheless encounter difficulties in interpreting those graphs, particularly when it comes to visualising changes that affect the slopes and positions of the curves in the IS-LM model.

The interactive simulation computer program presented here allows students to overcome basic difficulties in the visual comprehension of the curves used in the model. With this program, the students can thus visualise the changes in these curves when the values of the parameters in the model are modified. It also permits students to associate the
changes in those values with their effects on the economy and to understand the effects of fiscal and monetary policies in the short term under different circumstances.

The analysis of the scores obtained by the students of Macroeconomics I at the Business Administration School shows the advantages of using the simulation program both for class explanations and in doing individual work. The results of this analysis demonstrate that the average score of the students who used the simulation program was significantly higher than that of the rest of the students. These results could not be attributed to a lack of homogeneity among the students of the different groups.

It is therefore possible to conclude that the use of the simulation program in class – and its availability to the students to work on it – facilitates the teaching, learning and understanding of the IS-LM model and, through it, of the functioning of economic relations and the effects of fiscal and monetary policies in the short term. In this way, students are able to do more practical work and to view each case in stages, generating a greater understanding of the dynamics behind each particular scenario. In this sense, it is desirable to pose specific questions to guide the tasks undertaken by students, and to facilitate their learning in a stage by stage manner. It is also desirable that the teacher demonstrates some exercises to the students and teaches the students how to go about solving other problems.

Indeed, perhaps the success of this program has been that students were able to do more practical exercises and in an autonomous way. In this sense, it may be worthwhile for more studies to be performed to examine the reasons behind the success of such simulators for teaching. Thus, it may be worthwhile to accompany evaluations of simulators with surveys to students who use them, and to identify what aspects of the simulators not only provide the greatest benefits to learning, but also what their weaknesses may be.

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Note

The copyright of the IS-LM simulator belongs to the authors Pablo-Romero and Del-Pozo. Readers can access the program by contacting Dr. Pozo-Barajas by email (pozo@us.es).

References


Development of a Web-based System to Support Self-Directed Learning of Microfabrication Technologies

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ABSTRACT

Having engineers in microfabrication technologies educated has become much more difficult than having engineers educated in the traditional technologies, and this may be because of the high cost for acquirement of equipment, materials, and infrastructural means (i.e., cleaning rooms), all in addition to the hands-on practices that are often times time-consuming to perform. These factors pose challenges for improvements to be made in teaching and learning quality. The current study has designed an interactive learning system to support self-directed learning of microfabrication technology with both the technical and the functional viewpoints taken into consideration, along with evaluated results obtained from the end-users. The current study applied technology in virtual-reality in order for interactions to be carried out on the Internet, which permits the students to become familiarized with the techniques used in microfabrication technology as they learn to operate machines. The courses offered in microfabrication technology were incorporated with the developed web-based learning system, where effects of the blended methodology on student learning result were examined.

Keywords

Microfabrication technology, Technological education, Self-directed learning, Blended learning approach

Introduction

Microsystems, often referred to as microelectromechanical systems (MEMS), are miniaturized mechanical and electrical systems with a dimensional range within a few micrometers, and they include a wide range of applications in the automotive (Caliano et al., 1995; Barbour et al., 1997; Gripton, 2002), communications, biomedical industries, and process control. Applications in recent times include crash sensors in airbag systems, ink jet print heads, and pressure sensors. Several industrial surveys have shown a 16% growth in sales for microsystem-based technologies on the annual basis and are expected to reach more than twenty-five billion dollars by the year 2009 (Neuy, 2006).

The demands for microsystems are on the rise. Since the educational institutions are not sufficient enough to provide students with training in order to have desirable microsystems built, students are unable to have the needs of the industry met. The current teaching method for microfabrication technology relies vastly on experiments done where the students are presented with technical problems, the solutions, the expected results, and analysis that are already done on the results. All things considered, it is difficult for students to have the mistakes that they make reviewed while the experiment is being performed, which poses a major hindrance to have teaching quality improved.

Provided, the web-based system that has been developed in this study allows students to work on exercises on the Internet so that a decrease in the error rates can be expected while an increase in learning performance predicted. It is supposed that self-directed learning might encourage students to learn inductively with the aid of teaching systems.

Moreover, since self-directed learning (SDL) has claimed to have increased students’ confidence and capacity for independent learning in educational, as well as work environments that are dynamic (Levett-Jones, 2005; Nolan, 1997a), the attention that it has received has increased significantly, especially with the courses offered in higher education. Knowles (1975) has defined SDL by suggesting that learners who take the initiatives tend to learn more effectively than those who wait passively to be taught. Although there are advantages that have reportedly been induced by SDL (Kolb 1984; Boud et al., 1985; Burnard 1988 : Leonard, 1993; Nolan 1997a; Knowles, 1998; Levett-Jones, 2005 : Bary & Rees, 2006), some other research studies have reported otherwise and argued that the use of the SDL instructional methodology alone caused disaffection, resistance, and resentment in students (Townsend, 1990; Turunen et al., 1997). Turunen et al. (1997) pointed out that most students prefer a teacher-
centered approach to learning instead of a student-centered approach. Nolan (1997b) also stated that students prefer more of a teacher-centered model, as Le vett-Jones (2005) also indicated that successful introduction of SDL into the curricula requires a balance between the two. For instance, Bary and Rees (2006) conducted research on the learning of the English language and found that a “classical” approach aimed at acquiring the fundamental knowledge, which paralleled with self-directed learning, and thus allowed the students to explore the subject in detail on their own terms.

The method of self-directed learning empowers the students to investigate freely in devising the experimental procedures and deciding on how the results are interpreted. Long (2010) pointed out the six cognitive skills that are particularly important to successful self-directed learning: goal setting, processing, cognition, competence (or aptitude), decision-making, and self-awareness. In other words, effective self-directed learning depends on gathering of information and monitoring learners’ cognitive reactions to stimuli. A case in point: The Internet has enabled learning at each individual’s own pace, being completely free from curricular obligations; some of the frequently used electronic search engines such as Google Scholar and CiteSeer Research Index make it possible for students to achieve such goals (Desikan et al., 2005). Researchers have recently attempted to have e-learning technologies applied to processes of self-directed learning. Idros et al. (2010) sought to reignite enthusiasm in students to enhance self-directed learning skills through a system called “e-SOLMS,” for instance, while Liu (2009) built a web-based course for self-directed learning in psychology. The one thing in common for these two research papers was the capability of this system to present course contents (i.e., audio files, video files, and text files), and another was their introduction of self-directed learning (SDL) into the curricula using the student-centered approach. However, this approach would not be ideal for courses that concentrate on experimentations and hands-on exercises, yet, recent technological development of virtual reality (VR) has nevertheless promoted teaching with the use of three-dimensional (3-D) models.

The advancements in optical-fiber networks have made real-time transmissions of a large amount of data possible. Through the use of 3-D models and video images, connections are made among remote spots through the broadband network (Paquette, Ricciardi-Rigault, Paquin, Liegeois, & Bleicher, 1996). The field of virtual reality (VR) is expanding rapidly and it now includes a growing variety of 3-D models on computer hardware for real-time interactions (Sung, Ou, 2003). Though, an educational virtual environment (Bouras, Philopoulos, & Tsiatsos, 2001) provides a unique case of a VR system that emphasizes more on education and collaboration than on simulation.

**Web-based environment for self-directed learning**

Web2.0 was employed for technology of virtual-reality. The application was driven by a web server and Java applications while the presentation by a client-side terminal that is comprised of HTML, XML, and a 3-D web player plug-in. The client provides a student interface that handles input and output. The web server executes and performs computations based on student input using the XML and JSP languages. The application server reads and writes by JavaBean and interfaces with external software packages. Web pages written in HTML are used mainly for presenting the contents of the courses and/or performing automated processing on documents. For the development of the course structures, eXtensible Markup Language (XML) was used, and JAVA language was used for acquiring cross-platform applications and developing web pages that are interactive.

The process of microfabrication entails crystal growth, coating, packaging, and inspection. It was completed with virtual machines and laboratories designed (see Figures 1 & 2) in the current study. To engage students in the virtual laboratories, multiple interactive functions were made accessible to them—path design, parameter selection, view angle, and animation, as well as zoom, pan, rotation, machine, and working table navigating functions, also, selections of “events,” “animations,” or “simulations” can be made on a repeated basis so that the processes can be better understood. The observations made of the manufacturing processes fueled the adaptive selection stimulated and can be broken down: Onset of event → observations of manufacturing process → interpretation → assimilation → simulating developments of the observed micro products. The content for the learning of the microfabrication processes was extracted from the database based upon the group technology approach, where the procedures were displayed for the learning of the principles used in the stage of planning. After being selected, the manufacturing method for each of the microfabrication feature was delivered to students by virtual laboratories.
The creative problem-solving (CPS) theory was employed to develop the self-directed learning activities for technological education in the study. The guidelines and the results anticipated were provided in advance for the first type of CPS work, which is the type of work that introduces the students to relevant concepts that are fundamental and are involved in the design and fabrication of micro level devices. After students have gauged the interrelationships among the various related disciplines, they were expected to be able to explore methods of their choosing in finding solutions to the technological problems presented. Thus, the desired outcomes were not made available to students in the second type of CPS work; they were given only guidelines as for how to go about solving problems in the third type of CPS work. Students were confronted with problems only in the last type of CPS work, where they were asked to pursue solutions to have open-ended problems deciphered. Essentially, they were expected to formulate questions, investigate, plan design, collect and analyze information, and finally, have the final product produced. Figure 3 shows an example of a lesson that utilizes CPS for packaging and testing of the LED cap light.
Research question and population

The goals of the present study are to: (1) make students respond to the developed web-based environments that are interactive, and (2) investigate the effects of such environments on the learning of the technical skills, more specifically, microfabrication technology. The two classes that have been chosen were taught by the same instructor and the course was of the undergraduate level. Students were required to take the course of “Introduction to Micro-electro-mechanical System” to familiarize themselves with the fundamental concepts, and then they were asked to take the course of “Microfabrication Technology” to have a comprehensive understanding of the microfabrication technical skills. The participants in the Experimental group were comprised of 45 students in their senior year, while the Control group was comprised of 30 senior-year students, who were trained under the conventional learning environment, whereas the students in the Experimental group were trained for microfabrication technology with the support of the interactive, web-based environments. The hypothesis that “the developed web-based environments that are interactive have a positive effect on student technical skills in microfabrication technology” was tested, and the premise was that students of the two groups had equal prior knowledge and skills, or in other words, that the baseline drawn was objective. First examined was the prior knowledge of microfabrication in students. Fifty multiple-choice questions in the Cognitive Aptitude Test (Table 1) showed that there were no observable differences \( (p > .05) \) in terms of prior knowledge among students from the Experimental and Control groups before their participations in the microfabrication course. This indicates that before the experimental teaching had taken place, there were no differences noted in cognition in the students from the two groups. The results indicated that the hypothesis for the study was reasonable.

Table 1. Comparison of cognition between students from the experimental and control groups

<table>
<thead>
<tr>
<th>Group</th>
<th>Control group (n=30)</th>
<th>Experimental group (n=45)</th>
<th>( p )</th>
<th>t</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean SD</td>
<td>Mean SD</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre-course Cognition</td>
<td>57.65 11.82</td>
<td>58.24 11.23</td>
<td>.682</td>
<td>-.412</td>
</tr>
</tbody>
</table>

\(* p < .05\)

Research setting and methods

The effects of the interactive, web-based learning environment developed were examined quantitatively, as well as qualitatively. The quantitative analysis was drawn based on pretest and posttest scores; both of the pre- and post-tests were administered in the first and the final week of the 18-week semester term. The qualitative data were collected after interviews were conducted at the end of the courses, along with questionnaires administered to measure levels of satisfaction among participants toward the courses and their perceptions of the teaching methods used after completion of the courses. The course structure presented, the self-directed learning approach, as well as the interactions exchanged were among the items that were examined. The Cronbach’s alpha value of internal consistency was 0.769, which translated into strong reliability, as the criterion validity was based on the significantly positive correlation of test scores for several universities.

Results and discussion

Table 2 shows the participants' responses for items that were associated with their levels of satisfaction on the web-based learning interactions. The results showed that 93.3% of the participants agreed that the web-based learning interactions helped them with their problem-solve skills with the utilization of microfabrication technologies \((M = 4.15; \, standard \, deviation, \, SD = 0.521)\), while 90.0% of the participants believed the interactive learning environments to have been a conducive learning environment \((M = 3.98, \, SD = 0.632)\).

Table 3 illustrates the students' perceptions on the various features of the web-based learning environment. Nearly ninety percent of the students surveyed agreed that the interface design was user-friendly and thought the content of the course "well-organized." They also felt that the interactive web-based learning environments were able to facilitate the investigation and planning of activities in the microfabrication laboratory, which made microfabrication technology more appealing to them. The students believed that such environments not only improved their technological skills but also enhanced their ability to integrate the learned technologies with the theories studied.
However, a few participants felt isolated while completing assignments in the web-based learning environments, possibly due to the lack of face-to-face interactions involved. The interviews revealed that most students believed the course to be challenging, intellectually stimulating and engaging, and they have also offered positive feedback toward microfabrication technology.

**Table 2. Satisfaction with the interactive web-based learning environments**

<table>
<thead>
<tr>
<th>Items</th>
<th>Responses</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>The interactive web-based learning systems helped me to solve problems on MEMS technologies.</td>
<td>SA</td>
<td>13</td>
<td>A</td>
<td>25</td>
<td>US</td>
<td>7</td>
<td>DA</td>
<td>0</td>
</tr>
<tr>
<td>The interactive web-based learning systems provided a conducive learning environment.</td>
<td>SA</td>
<td>10</td>
<td>A</td>
<td>27</td>
<td>US</td>
<td>6</td>
<td>DA</td>
<td>2</td>
</tr>
</tbody>
</table>

*Note: SA = Strongly Agree (5), A = Agree (4), US = Unsure (3), DA = Disagree (2), and SDA= Strongly Disagree (1), M = Mean, SD = Standard Deviation*

**Table 3. Perceptions of the interactive web-based learning environments**

<table>
<thead>
<tr>
<th>Items</th>
<th>Responses</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>The interactive web-based learning system enhanced my interests toward learning of microfabrication technology.</td>
<td>SA</td>
<td>13</td>
<td>A</td>
<td>25</td>
<td>US</td>
<td>7</td>
<td>DA</td>
<td>0</td>
</tr>
<tr>
<td>It was easy to gain access to technical support.</td>
<td>SA</td>
<td>10</td>
<td>A</td>
<td>27</td>
<td>US</td>
<td>5</td>
<td>DA</td>
<td>3</td>
</tr>
<tr>
<td>The course materials satisfied my learning needs.</td>
<td>SA</td>
<td>6</td>
<td>A</td>
<td>20</td>
<td>US</td>
<td>9</td>
<td>DA</td>
<td>6</td>
</tr>
<tr>
<td>The interface is user friendly and attractive.</td>
<td>SA</td>
<td>15</td>
<td>A</td>
<td>22</td>
<td>US</td>
<td>8</td>
<td>DA</td>
<td>0</td>
</tr>
<tr>
<td>The online course contents were well structured.</td>
<td>SA</td>
<td>11</td>
<td>A</td>
<td>22</td>
<td>US</td>
<td>9</td>
<td>DA</td>
<td>3</td>
</tr>
<tr>
<td>I was able to obtain the materials from the interactive web-based learning system for learning.</td>
<td>SA</td>
<td>9</td>
<td>A</td>
<td>23</td>
<td>US</td>
<td>10</td>
<td>DA</td>
<td>3</td>
</tr>
<tr>
<td>The interactive web-based learning systems encouraged learning.</td>
<td>SA</td>
<td>17</td>
<td>A</td>
<td>22</td>
<td>US</td>
<td>6</td>
<td>DA</td>
<td>0</td>
</tr>
<tr>
<td>I obtained feedback from interactive web-based learning systems as frequently as needed.</td>
<td>SA</td>
<td>13</td>
<td>A</td>
<td>26</td>
<td>US</td>
<td>6</td>
<td>DA</td>
<td>0</td>
</tr>
<tr>
<td>I was able to interact with the web-based learning systems as frequently as needed.</td>
<td>SA</td>
<td>15</td>
<td>A</td>
<td>24</td>
<td>US</td>
<td>6</td>
<td>DA</td>
<td>0</td>
</tr>
<tr>
<td>I was able to obtain assistance in understanding content that is related to microfabrication with use of interactive web-based learning systems.</td>
<td>SA</td>
<td>9</td>
<td>A</td>
<td>25</td>
<td>US</td>
<td>8</td>
<td>DA</td>
<td>3</td>
</tr>
<tr>
<td>I was able to understand the microfabrication course content from interactive web-based learning systems.</td>
<td>SA</td>
<td>11</td>
<td>A</td>
<td>24</td>
<td>US</td>
<td>7</td>
<td>DA</td>
<td>3</td>
</tr>
<tr>
<td>The use of materials in the interactive web-based learning systems enhanced my understanding of the microfabrication technology.</td>
<td>SA</td>
<td>6</td>
<td>A</td>
<td>24</td>
<td>US</td>
<td>7</td>
<td>DA</td>
<td>4</td>
</tr>
<tr>
<td>I would like to repeat the experience.</td>
<td>SA</td>
<td>23</td>
<td>A</td>
<td>17</td>
<td>US</td>
<td>5</td>
<td>DA</td>
<td>0</td>
</tr>
</tbody>
</table>

**Table 4. Comparisons of Pre-and Post-Test scores for the undergraduate students**

<table>
<thead>
<tr>
<th>Control group (n = 30)</th>
<th>Experimental group (n = 45)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-test</td>
<td>Post-test</td>
</tr>
<tr>
<td>M</td>
<td>SD</td>
</tr>
<tr>
<td>Operation of machines</td>
<td>7.70</td>
</tr>
<tr>
<td>Selection of process parameters</td>
<td>7.93</td>
</tr>
<tr>
<td>Process planning</td>
<td>7.20</td>
</tr>
</tbody>
</table>

*The maximum grade for each part of the question was 10.00, and the maximum grade for the entire question was 30.00.*
Learning effectiveness was analyzed by giving the students exercises to work on in the lab setting. Table 4 shows the mean scores for technical skills, which included “operation of machines,” “selection of process parameters,” and “process planning,” before and after attending the microfabrication course with the implementation of the interactive web-based environments. The Experimental group (i.e., blended learning environment) achieved significant improvements in its scores for “operation of machines” ($t = -5.046$, $p = 0.000$), “selection of process parameters” ($t = -3.613$, $p=0.001$), and “process planning” ($t = -3.778$, $p = 0.000$), whereas the Control group (i.e., the conventional learning environment) has shown no significant improvements (see Table 4).

In order to obtain more insight on the above quantitative findings, the 2-way ANOVA was used to analyze the students’ technical skills, which included “operation of machines,” “selection of process parameters,” and “process planning.” In the aspect of operation of machines, both the group effect and the pretest-posttest design have delivered findings that have been found to be statistically significant, as shown in Table 5, which indicates that a blended learning environment is instrumental in producing improved learning outcomes. Table 6 shows that the group effect has not been drastic ($F = 1.147, p = .288$), while the pretest-posttest design generated noticeable effects ($F = 8.936, p = .004$), suggesting that in general, the students’ test scores have improved. However, the effects of a blended learning environment have not been found to be as drastic in the learning of the selection of process parameters, and this might have been associated with the technical obstacles encountered with the applied technique of virtual reality that have mainly concentrated on the simulations of operations of object, aside from the sequences of these operations.

Table 5. Analysis of variance for operation of machines

<table>
<thead>
<tr>
<th>Source</th>
<th>SS</th>
<th>df</th>
<th>MS</th>
<th>F</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group</td>
<td>5.601</td>
<td>1</td>
<td>5.601</td>
<td>4.481*</td>
<td>.038</td>
</tr>
<tr>
<td>Pre-Post-test</td>
<td>12.721</td>
<td>1</td>
<td>12.721</td>
<td>22.231**</td>
<td>.000</td>
</tr>
<tr>
<td>Interaction</td>
<td>1.868</td>
<td>1</td>
<td>1.868</td>
<td>3.264</td>
<td>.075</td>
</tr>
<tr>
<td>Pre-post-test error</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>subject</td>
<td>91.239</td>
<td>73</td>
<td>1.250</td>
<td></td>
<td></td>
</tr>
<tr>
<td>residual</td>
<td>41.772</td>
<td>73</td>
<td>.572</td>
<td></td>
<td></td>
</tr>
<tr>
<td>total</td>
<td>149</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

$p < .05, p < .01$

Table 6. Analysis of variance for selection of process parameters

<table>
<thead>
<tr>
<th>Source</th>
<th>SS</th>
<th>df</th>
<th>MS</th>
<th>F</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group</td>
<td>1.138</td>
<td>1</td>
<td>1.138</td>
<td>1.147</td>
<td>.288</td>
</tr>
<tr>
<td>Pre-Post-test</td>
<td>8.604</td>
<td>1</td>
<td>8.604</td>
<td>8.936**</td>
<td>.004</td>
</tr>
<tr>
<td>Interaction</td>
<td>3.004</td>
<td>1</td>
<td>3.004</td>
<td>3.120</td>
<td>.082</td>
</tr>
<tr>
<td>Pre-Post-test Error</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>subject</td>
<td>72.422</td>
<td>73</td>
<td>.992</td>
<td></td>
<td></td>
</tr>
<tr>
<td>residual</td>
<td>70.289</td>
<td>73</td>
<td>.963</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>149</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**$p < .01$**

The lack in real-time presentations of the produced scientific results pose great hindrance in keeping students from adjusting the process parameters effectively for that they were unable to distinguish the varying machining outcomes produced by the different process parameters utilized. However, such technical issues may be greatly mitigated with the software and hardware technologies becoming more advanced in the future.

In the aspect of the operation of machines, the analysis has illustrated that interactions have been taking place between the group effect and the pretest-posttest design ($F = 6.095, p = .016$, interaction is significant), which thus requires the analysis be scrutinized in a more precise manner. Nonetheless, the simple main effect of the group factor has demonstrated that the pretest scores produced by the Control group shares virtually no differences from that that was produced by the Experimental group, while the posttest scores suggest a tremendous amount of differences between the two groups (Table 8). Moreover, the simple main effect of the pre-post-test factor suggests that the conventional teaching techniques served little purposes in improving test scores amongst students in the
Control group (Table 9). Furthermore, the blended teaching environment has been statistically proven to be facilitating students in the Experimental group to deliver higher test scores (Table 10).

<table>
<thead>
<tr>
<th>source</th>
<th>SS</th>
<th>df</th>
<th>MS</th>
<th>F*</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group</td>
<td>5.444</td>
<td>1</td>
<td>5.444</td>
<td>5.103*</td>
<td>.027</td>
</tr>
<tr>
<td>Pre-Post-test</td>
<td>10.671</td>
<td>1</td>
<td>10.671</td>
<td>7.915**</td>
<td>.006</td>
</tr>
<tr>
<td>Interaction</td>
<td>8.218</td>
<td>1</td>
<td>8.218</td>
<td>6.095*</td>
<td>.016</td>
</tr>
<tr>
<td>Pre-Post-test</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>subject</td>
<td>77.889</td>
<td>73</td>
<td>1.067</td>
<td></td>
<td></td>
</tr>
<tr>
<td>residual</td>
<td>98.422</td>
<td>73</td>
<td>1.348</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>149</td>
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<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*p < .05, **p < .01

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>t</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-test</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control group</td>
<td>30</td>
<td>7.2000</td>
<td>.96132</td>
<td>.308</td>
<td>.759</td>
</tr>
<tr>
<td>Experimental group</td>
<td>45</td>
<td>7.1111</td>
<td>1.36885</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Post-test</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control group</td>
<td>30</td>
<td>7.2667</td>
<td>.90719</td>
<td>-3.836*</td>
<td>.000</td>
</tr>
<tr>
<td>Experimental group</td>
<td>45</td>
<td>8.1333</td>
<td>.99087</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**p < .01

Conclusions

The objects of this study are the courses offered in microfabrication technology that have their concentrations on experimentations as well as on practical training. This study has developed a web-based system that is interactive to support self-directed learning of the MEMS technologies, which incorporated the developed web-based system with the courses in question. The blended methodology allowed for a balanced combination of the teacher-centered teaching approach and the student-centered one. As it has been found, most students preferred the blended style of learning, and that the learning performance delivered by the Experimental group showed significantly higher effectiveness of the instructions provided, in terms of teaching of microfabrication. The students generally provided positive feedback regarding the self-directed navigation of the web-based learning system while participating in microfabrication courses. Most students also considered the blended learning system to have been helpful when it comes to learning the technical operations that are relevant to microfabrication; it has enabled the students to learn such operations on the Internet on a persistent basis that familiarized them with microfabrication technologies.

The web-based learning system that has been developed out of this study not only assisted students to operate the MEMS and the related manufacturing techniques, it also allowed for process planning to be achieved in cyberspace and was well-received by the students. In the field of technological education, although there had been researchers...
that have turned experimental equipment into virtual machines and have provided such innovation to students for them to create simulations of the different experimental conditions (such as traditional machining and electrical laboratory), operations of such web-based virtual machines are actually simple to achieve, and therefore it has been difficult to assess the actual attributions that applications of such technologies have made when utilized in teaching. With technological education in microfabrication, on the other hand, since the needs for the required hardware usually consume an enormous amount of resources and since an experiment is often conducted in a space where there is vacuity, it is relatively simple to assess the actual usefulness of the applied techniques that are driven by virtual-reality technologies. In addition, since the students are able to conduct experiments on a repeated basis that permits them to learn the errors that they have made when they are still in the middle of the experiment that is being conducted, they become even more familiarized with the procedures and are more able to have their error rates mitigated.

Courses with concentrations on experimentations and practical training are notably difficult to teach in virtual reality because of their needs for physical spaces such as laboratories, and how engineering education can be offered on-line without being restrained by such physical limitations and yet with quality, scale, and breadth deserves more attention. The endeavor shall encourage online engineering education to become more widely accepted and applied further.

Acknowledgments

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References


Peer Evaluation in Blended Team Project-Based Learning: What Do Students Find Important?

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ABSTRACT
Team project-based learning is reputed to be an appropriate way to activate interactions among students and to encourage knowledge building through collaborative learning. Peer evaluation is an effective way for each student to participate actively in a team project. This article investigates the issues that are important to students when evaluating their peers in team project-based learning. A message analysis framework was inductively derived for the study, and data collected from the team-project learning process were categorized within this framework. Each message type was analyzed with respect to the students’ peer evaluation results. The results showed that managerial, procedural, and social messages, rather than academic messages, significantly predicted peer evaluation results. These results indicate that students find social contributions, such as organizing or coordinating managerial abilities, more important than cognitive contributions when they evaluate peers. Additional results and the significance of their implications are discussed.

Keywords
Peer evaluation, Students’ evaluation, Blended team project-based learning, Group learning evaluation

Introduction
In recent years, there has been an increasing demand for the development of effective teaching methods and instructional strategies to improve the quality of university education. Most university Centers for Teaching and Learning (CTLs) have invested in program development to improve their teaching methods. Instructional design that facilitates student-student interaction is considered to be an effective strategy to maximize learning through active student participation, which nurtures various social competencies during academic knowledge building.

Team project-based learning is one of the most commonly used methods to activate interactions among students. Team project-based learning has been introduced and is increasingly used as a teaching and learning method in higher education to promote knowledge building through social interaction (Von Kotze & Cooper, 2000). The Korean National Human Resources Development Council, an organization devoted to cultivating creative human resources, reports that team project-based learning has attracted educators’ attention as an alternative teaching method for both improving the quality of teaching and enhancing learning effectiveness in higher education through social learning (Jung, 2001). In addition, team project-based learning promotes higher learning skills including cooperative ability, critical reasoning, creative thinking, responsibility, and communication (Moursund, 2003). A social learning context thus promotes both students’ social and cognitive learning. Team project-based learning allows students to engage in the practice of knowledge building through a process of social investigation in a meaningful context. Therefore, teamwork competencies including communication, leadership, collaboration, and interpersonal relations, can be acquired during team-based social activities rather than in lectures or in individualized tasks. Many reports have been published outlining the advantages of online (or blended) team-based learning, e.g., student participation and interaction (Pena-Perez, 2000), social knowledge building (Stahl, 2000; Gunawardena et al., 1997), and critical thinking in online learning (Bullen, 1998; Newman et al., 1995).

However, there are also noted disadvantages of this type of team-based learning. Social loafing is the phenomenon of people exerting less effort to achieve a goal when they work in a group than when they work alone (Karau & Williams, 1993). Its two common manifestations are (1) Free-rider effect, where some members do not put in their share of work under the assumption that others’ efforts will cover their shortfall, and thus cause (2) Sucker effect, where the other (fully performing) members lower their efforts in response to the free-riders’ attitude (Kerr & Bruun, 1983; Salomon & Globerson, 1987). This type of social laziness indicates that team-based learning does not guarantee effective interactions in the classroom. Additionally, instructors are often overloaded with tasks to provide prompt and timely feedback for students to lessen social laziness because providing enough feedback is very effort-intensive (Dunlap, 2005; Ertmer, et al., 2010). The negative side effects of team-based learning may be difficult to resolve because an instructor may not observe all the processes occurring within the student groups. Typically, instructors evaluate the quality of the final product without knowledge of the team work process.
Peer evaluation may be a good strategy to monitor the dynamics within the group. Peer evaluation is an effective way of allowing every student to participate in team-based learning and monitor the process, as well as the product, of team learning. Peer evaluation is useful in higher education contexts because it is also expected to decrease instructors’ workloads (Ertmer et al., 2010). However, peer evaluation has not been used extensively due to instructors’ perceptions that such evaluations lack credibility. Student evaluation, although it effectively motivates students, has been considered less reliable than instructor evaluation. This controversy may arise from the fact that teachers and students evaluate different things. If instructors and students in fact evaluate different aspects of the learning process, this controversy should not be a matter of reliability or credibility. However, research on whether students and teachers evaluate the same criteria is scarce.

Therefore, this study investigated what students find important in their peer evaluations in team project-based learning. To facilitate data collection enabling the tracking of student activities, the team project-based learning in this study was implemented in a blended e-learning environment so that students’ interactions could be recorded on the website easily. A blended team-based learning mode is similar to offline team-based learning except that students’ interactions - both synchronous and asynchronous - are easily recorded on the website. This system enables students to reflect on what they have performed and allows teachers to track students’ learning processes more easily. In our case, student activities recorded on the class website were primarily in the form of text messages. These messages were categorized and coded using a novel message analysis framework developed for this research. Regression analysis was run on the categorized messages and peer evaluation results in order to determine what components students consider to be important when evaluating their peers. The results have significant implications for quality team-based learning in higher education.

Theoretical Background

Peer Evaluation

Peer evaluation is a process in which students evaluate their peers’ performance during group work or in class (Kane & Lawler, 1978). Research on peer evaluation within student groups has mostly focused on whether it is as credible as teacher evaluation. The credibility and effectiveness of peer evaluation are supported by many studies showing that peer evaluation is as valid as instructors’ evaluations (Falchikov & Goldfinch, 2000; Weyer et al., 2011). Gerard (2002) insisted that peer evaluation is a predictor of long-term success and the best indicator for evaluating performance. Peer evaluation is also reported to encourage individual responsibility (Liu et al., 2002) and to provide students the opportunity to reflect on their own work and to compare their work with that of others, which enhances students’ meta-cognitive perception (Topping et al., 2000).

Peer evaluation, however, has also been criticized with respect to fairness. Brindley and Scofield (1998) report that when the peers know one another, they do not assign each other poor scores, even when their performance is poor. Chang et al. (2011) also reported peer evaluation is not valid and reliable in their experimental study. A major weakness of peer evaluation was reported to be grade inflation or deflation (Balint et al., 2002). Students may take advantage of the system to raise their own grade. Conversely, some students may also be overly critical of their own performance and deflate their own scores (Blanche, 1988). In addition, the discrepancy between the ratings of students and experts is reported to be higher in group-work assessments than in individual-work (Sung et al., 2010).

These arguments collectively suggest that there are often differences in the results of evaluations performed by a teacher and those completed by students. However, many studies have apparently overlooked the features of students’ performance that are being evaluated. Differences in evaluation results, if any, may be related to the fact that the evaluators have different points of view. Students may evaluate different aspects of their peers’ performance than teachers do, precisely because they have a different vantage point from which to measure other students’ work. Therefore, judging that peer evaluation lacks credibility based on only a teacher’s viewpoint might be unfair. If students and teachers simply evaluated different things, the difference in evaluation results should not be a matter of reliability, and then student evaluations should not be given less weight than teacher evaluations.
Message Analysis Frameworks

Existing message analysis frameworks were not adequate for analyzing messages concerning students’ interactions for this study. Message transcripts are a useful resource for investigating psycho-social dynamics, as Henri (1992) has indicated. Many message analysis frameworks have been presented in previous studies (Bullen, 1998; Fahy, 2001; Gunawardena et al., 1997; Henri, 1992; Newman et al., 1995; Zhu, 1996). In the early stage of message analysis framework development, Henri (1992) attempted to analyze student cognition from an interaction analysis and developed a content-analysis framework with five categories: participatory, social, interactive, cognitive, and meta-cognitive. However, although her framework provoked research on content analysis, these five categories proved to be ambiguous because they are not completely independent, and thus the categories do not have equal levels of orthogonal dimensions. For example, the ‘participatory’ and ‘interactive’ categories are behavioral, whereas the ‘cognitive’, ‘meta-cognitive’, and ‘social’ categories are thematic. Cognitive messages could be interactive and participatory, and of course, vice versa. Gunawardena et al. (1997) also reported problems using Henri’s (1992) model to distinguish between cognitive and meta-cognitive activities in conferences due to the lack of precise criteria defining each category.

In fact, many message analysis frameworks have been criticized for category ambiguity, e.g., multiple postings in few categories (Gunawardena, et al., 1997) or messages coded into more than one category (Zhu, 1996). According to Fahy (2001), discriminant capability and reliability among users have been major problems in previous transcript analysis work. Discriminant capability refers to the function of a coding instrument that permits the direct and unambiguous placement of message content into discrete and useful categories. A lack of discriminant capability directly effects reliability, since unclear categories lead to discrepancies in coding. Furthermore, the previously developed instruments have tended to be too complex and contain too many codes, which hinder their application. Gunawardena et al. (1997) represented 20 categories in five phases, Cookson & Chang (1995) developed 16 codes, and Rourke et al. (2001) used 12 indicators. In addition, inter-coder reliability has often not been clearly delineated.

Regarding message content type, there are some content analysis frameworks specifically designed for capturing critical thinking processes (Bullen, 1998; Fahy, 2001; Newman et al., 1995). However, the cooperative interactions in team project-based learning differ from critics occurring in debates. Furthermore, the units of content analysis are diverse, including sentences, messages, and thematic units. For example, Fahy (2001) insisted that the data unit of a transcript analysis should be the sentence. Fahy appears to focus more on the format of the transcript rather than on the ‘meaning’ itself. However, we sought to uncover what students consider to be important in interactions with their peers. Therefore, an analysis based on units of meaning rather than sentence format was deemed more valid for this study precisely because there may be several meanings encoded in one sentence or only one meaning spanning several sentences.

In summary, the message analysis frameworks reported in the previous literature are conceptual frameworks derived deductively based on the researchers’ logic. Those frameworks are not applicable to real message coding in our case study because they are not drawn from the actual coding of the messages found in an online team project-based learning context. Therefore, we inductively developed a new message analysis framework to clarify the analytic categories, which is described in the following section.

Research Methodology

Developing a Message Analysis Framework

To develop a message analysis framework, a thematic unit was defined as a coding unit. A primary coding scheme was then extracted from the existing literature (Bullen, 1998; De Wever, et al., 2006; Fahy et al., 2001; Gunawardena et al., 1997; Henri, 1992; Newman et al., 1995; Oren et al., 2002; Pena-Shaff & Nicholls, 2004; Zhu, 1996). Among the previous works consulted, the framework of Oren et al. (2002) was deemed to be the best fit for the macro categories analyzed in this study. Herein, cognitive messages are related to academic processes, whereas social messages are not focused on the academic content itself but instead concern building interpersonal relationships that foster smooth progress in a collaboration. Procedural messages include scheduling, timetables, to-do lists, and other various procedures related to the learning process. Each researcher independently conducted primary coding using these three macro-categories. Coding revisions were iterated for each category to better delimit the message categorization.
### Table 1. The message analysis framework developed for this study

<table>
<thead>
<tr>
<th>Categories of Oren et al. (2002)</th>
<th>Newly elaborated categories in this research</th>
<th>Definition</th>
<th>Student Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cognitive (academic)*</td>
<td>Intellectual</td>
<td>Academic intellectual messages including activities for cognition, reflection, judgment, structuring, knowledge building, criticism, reasoning, and those related to the academic content.</td>
<td>The author seemed to suppose that there were two types of instructional design and management styles. However, most practice lies in the middle of two extremes. Why do we need to compare structured instruction and interactive instruction? We need to implement both as much as we can. It is not a problem of selection. In my opinion, we need to add this point to our work. What do you think?</td>
</tr>
<tr>
<td></td>
<td>Informative</td>
<td>Academic, learning-content related but not related to the original intellectual activity, instead derived mainly from information from other resources and references.</td>
<td>Attached file is the history of modern France royal family which I found on the internet for reference… Attachments: france-history.doc</td>
</tr>
<tr>
<td></td>
<td>Social</td>
<td>Messages used mainly for social purposes, not related to academic learning content.</td>
<td>Hi, all, the weather outside is too good for us to study all day long, isn’t it? -.-;; But we’re almost here, to the final goal, hurray!! Everybody, cheer up! ^_^…</td>
</tr>
<tr>
<td></td>
<td>Diplomatic</td>
<td>Messages not used primarily for social purposes but rather to facilitate smooth communication; additional diplomatic sentences at the beginning or end of the main message.</td>
<td>I really appreciate your opinion. I’m so impressed by your insightful point. I agree some part of your suggestion. However,…</td>
</tr>
<tr>
<td></td>
<td>Managerial</td>
<td>Messages regarding who does what and how, task allocation, coordination, organization, and mediation.</td>
<td>.Ok, then let’s wrap up our talking. Now A take part 1 and B take part 2. and C ‘d better review A &amp; B’s work upon their request. If there is any problem, we can talk on chatting board and get to consensus, all right? …</td>
</tr>
<tr>
<td></td>
<td>Procedural (operational)*</td>
<td>Messages related to procedures: scheduling, deadline management, assignment due date of the coursework.</td>
<td>…When is our assignment due? Where should we upload our progress on the class site? See you at 11:00 pm on the messenger…</td>
</tr>
<tr>
<td></td>
<td>Procedural</td>
<td>Messages about technical issues related to online learning activities</td>
<td>…Download the attached file and unzip it. Then click front.html. If you know how to use PHP, then it’ll be a lot helpful…</td>
</tr>
</tbody>
</table>

* Articulation of Oren et al. (2002)’s categories for this research are within the parentheses.

During the coding revision process, we found that the three macro-categories of Oren et al. (2002) required further elaboration. For example, cognitive messages on academic process should be differentiated into intellectual messages, i.e., those conveying students’ own ideas, and informative messages, representing the collection of ideas or references from on- and offline resources. In addition, social messages were also sub-categorized into multiple types. Oren’s social messages are related to general social relationships removed from academic content. However, we found that some messages directly served the purpose of building rapport while other messages relayed diplomatic courtesies before or after the main (either cognitive or procedural) message; these messages were not considered to be intended primarily for social relationship building. For our purposes, the former were classified as
social messages, whereas the latter were classified as diplomatic messages. Finally, procedural messages were differentiated into managerial, procedural, and technical messages. We defined managerial messages as messages concerned with who does what and how, task allocation, coordination, organization, and mediation. Procedural messages specifically concerned scheduling, deadlines, the assignment process or the coursework, etc., whereas technical messages were focused on technical issues related to online learning activities. Managerial, procedural, and technical messages are all related to ‘operation’ of the team process, whereas intellectual and informative messages are about ‘academic’ quality of the team product. Social and diplomatic messages contribute to the whole process more smoothly and communally, so it can be articulated as ‘relational’ category.

In summary, seven categories were inductively derived from Oren’s original three categories to comprise the content-analysis framework for this study (See Table 1): Cognitive (Academic: Intellectual, Informative), Social (Relational: Social, Diplomatic), and Procedural (Operational: Managerial, Procedural, Technical). Three external experts (PhDs in Educational Technology) reviewed all categorizations for verification. Inter-coder agreement among the external coders, based on Cohen’s Kappa Coefficient, was .87. Detailed development process of the message analysis framework is reported separately on Lee & Kim (2011).

Data Collection and Analysis

Thirty-two undergraduate students enrolled in Instructional Methods and Educational Technology at Seoul National University participated in this study. Their majors were diverse, including humanities, social science, natural science, and other subjects. The students in the class were organized into eight teams of four students each. Each team was assigned two project tasks: a theoretical review task and a development task. Although they were given the same task requirements, each team developed their own unique topic. Students interacted with their team members mainly through asynchronous online discussion boards several times a week (synchronous chatting board was also used but not as often as the asynchronous site). All students were very familiar with online communication. Student teams sometimes had offline meetings, but more often they met online, and all of their discussions and brainstorming ideas were recorded by a member of each group and uploaded on the team project website so that researchers were able to track and analyze students’ interactions. The instructor was able to read all of the recorded interactions on each team’s board but did not intervene during team communications. These team interactions included only communications among students within each team. If there were any general questions for the instructor, students posted their questions on the class Q/A board or asked the instructor directly via email.

Peer evaluations can involve peer nomination, peer rating, and peer ranking (Kane & Lawler, 1978). Peer nomination, for example, consists of nominating peers with the highest or the lowest performance in each of the evaluated items. This method is reputed to display the highest reliability and validity. Peer rating, known as the most useful method with the least bias, refers to simply rating peers on each of the evaluation items. Peer ranking involves ranking peers in relative order from the best performers to the worst performers. This last method may be the best way to differentiate each of the peer evaluation scores but has hardly been investigated. In this study, peer rating was used in the initial implementation, but the rating scores were translated into peer ranking because there were wide variations in the individual perceptions of the best and worst performers.

Peer evaluation was performed after two major team projects for each group during the semester. The peer evaluation report was not made public. The peer evaluation form used in this research included the following items: 1) Participated in group project or meetings; 2) Helped keep the group focused on the task; 3) Contributed useful ideas; 4) Quality of work performed; and 5) Quantity of work performed. Students were instructed to award up to five points for each item, for up to twenty-five total points on the evaluation form. Students were not permitted to assign the same score for every student Relative peer ratings, rather than the direct raw scores, were used for the analysis because the relative importance of student perceptions rather than the absolute scores was deemed more significant in this work. Additionally, each ranking was weighted. Because there were four members in each team, the rankings were from first to fourth, and the corresponding weighting values were from four to one. Thus, the first-ranked student received four points for each item, the second-ranked student received three points, the third-ranked student received two points, and the lowest-ranked student received only one point. These peer-ranking points were analyzed with respect to the content of the messages related to each category to determine what types of messages the higher-ranking students posted.
Results and Discussion

Finally, 773 postings were posted on the asynchronous board. These messages were categorized using the content-analysis framework and subsequently analyzed for correlation with the results of the peer evaluation by regression analysis. There were 1,814 thematic message units (there could be several thematic message units per one posting); including 560 intellectual, 256 informative, 161 social, 277 diplomatic, 108 managerial, 381 procedural, and 71 technical message units. The intercorrelations and descriptive statistics for all study variables are summarized in Table 2.

<table>
<thead>
<tr>
<th>Table 2. Intercorrelations and Descriptive Statistics for Study Variables</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intellectual</td>
</tr>
<tr>
<td>Peer evaluation</td>
</tr>
<tr>
<td>Intellectual</td>
</tr>
<tr>
<td>Informative</td>
</tr>
<tr>
<td>Social</td>
</tr>
<tr>
<td>Diplomatic</td>
</tr>
<tr>
<td>Managerial</td>
</tr>
<tr>
<td>Procedural</td>
</tr>
<tr>
<td>Technical</td>
</tr>
<tr>
<td>No. of units</td>
</tr>
<tr>
<td>Mean (SD)</td>
</tr>
</tbody>
</table>

Notes. No. of units indicates the minimum and the maximum number of the thematic message units. Mean is the average number of the thematic message units by each student. *p<.05, **p<.01

Managerial, Procedural, and Social Contributions

Students evaluated their peers’ managerial, procedural, and social contributions as being more important than cognitive contributions. Table 3 presents a summary of the regression results, showing that managerial, procedural, and social messages of student activities were significantly correlated with the peer evaluation results, whereas cognitive messages were not significant. This difference indicates that the students who conveyed more managerial, procedural, and social messages received higher scores from their peers, whereas cognitive message contribution did not significantly influence peer evaluation results.

<table>
<thead>
<tr>
<th>Table 3. Regression Analysis Results: Message Types Predicting the Overall Peer Evaluation Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variables</td>
</tr>
<tr>
<td>Intellectual</td>
</tr>
<tr>
<td>Informative</td>
</tr>
<tr>
<td><strong>Social</strong></td>
</tr>
<tr>
<td>Diplomatic</td>
</tr>
<tr>
<td>Managerial</td>
</tr>
<tr>
<td>Procedural</td>
</tr>
<tr>
<td>Technical</td>
</tr>
</tbody>
</table>

Note: Dependent variable is peer evaluation
*p<.05, **p<.01

Social messages acted as a type of lubricant that allowed the collaboration process to function more smoothly. Procedural and managerial messages led the progress of the team project and kept all team members working – one goal. The results indicate that students perceived the social role of harmonious collaboration and steady progress to be more important than cognitive contributions. Students seemed to perceive collaborative competency as more necessary for successful team learning than individual cognitive excellence.
This finding has significant implications for the debate on peer vs. instructor evaluation. When grading students, instructors usually cannot observe what occurs within each group. Therefore, their grading must be more focused on the academic achievement evident in the final product, regardless of the nature of the team’s collaborative process. Instructors rarely evaluate the process of teamwork or other social competencies, which, in addition to academic knowledge in each discipline, universities seek to nurture through their curriculum. Our results therefore imply that peer evaluation may be a good strategy for process evaluation and can supplement instructor evaluation.

**Intellectual Messages (Quality) vs. Informative Messages (Quantity)**

Analyzing these relationships in further detail (Table 4), we found that the numbers of informative and procedural messages specifically predicted scores on the peer evaluation question “participation in group project or meetings”. Procedural and diplomatic messages influenced the scores on “helped keep the group focused on the task”; social messages predicted “contributed useful ideas” scores. Informative, diplomatic, and procedural messages were related to the quantity of the work performed, whereas intellectual messages predicted the quality of the completed work.

As shown in Table 4, an interesting result emerged between informative messages and intellectual messages. Students’ evaluations of “informative” and “procedural” messages were predicted by the quantity rather than the quality of the work, whereas they considered “intellectual” messages to represent the quality of the work. This distinction supports two conclusions: 1) the findings justify the use of the newly modified message analysis framework in this study, in which “informative” messages are differentiated from “intellectual” messages, whereas both were categorized broadly into “academic cognitive” messages in the previous literature; and 2) student evaluation is quite reasonable because the students distinguished “intellectual” messages from others and credited these messages toward the quality of work.

In the previous literature, credibility or reliability issues have been reported as factors in the reluctance to adopt a wider use of peer evaluation, because it may often be perceived as an unfair evaluation method. However, the results of this study showed that students clearly distinguished quality contributions from quantity contributions and evaluated their peers quite reasonably in each area. This finding implies that peer evaluation is a valid and fair strategy to evaluate team members’ efforts and contributions.

Furthermore, although students evaluated “intellectual” messages as being related to the “quality of the work”, they did not count them as critical contributions, unlike the sum of other social and procedural messages. In other words, students considered “managerial”, “procedural”, and “social” messages to be the most important, although these were not “intellectual” messages. Social messages such as compliments and appreciation for other’s efforts were also evaluated positively in this research. Therefore, students seem to perceive that the most critical factor in team collaboration is not each individual’s intellectual participation but rather each team member’s social collaboration, which facilitates the progress of the project. Instructors would not be able to evaluate the various types of participation of each student within the group because instructor evaluations are usually based on the final product. The results of this study imply that peer evaluation can complement instructor-only evaluation.

<table>
<thead>
<tr>
<th>Peer evaluation question (Dependent variables)</th>
<th>Independent variables</th>
<th>Standardized coefficient</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Participated in group project or meetings</td>
<td>Informative</td>
<td>.606</td>
<td>8.098**</td>
</tr>
<tr>
<td></td>
<td>Procedural</td>
<td>1.174</td>
<td>3.869*</td>
</tr>
<tr>
<td>Helped keep the group focused on the task</td>
<td>Diplomatic</td>
<td>.606</td>
<td>5.743**</td>
</tr>
<tr>
<td></td>
<td>Procedural</td>
<td>1.174</td>
<td>6.039**</td>
</tr>
<tr>
<td>Contributed useful ideas</td>
<td>Social</td>
<td>.443</td>
<td>4.325*</td>
</tr>
<tr>
<td></td>
<td>Informative</td>
<td>.487</td>
<td>5.392**</td>
</tr>
<tr>
<td>Quantity of work performed</td>
<td>Diplomatic</td>
<td>-.831</td>
<td>5.301*</td>
</tr>
<tr>
<td></td>
<td>Procedural</td>
<td>.579</td>
<td>3.939*</td>
</tr>
<tr>
<td>Quality of work performed</td>
<td>Intellectual</td>
<td>1.150</td>
<td>4.119*</td>
</tr>
</tbody>
</table>

*p<.05, ** p<.01

Table 4. Regression Analyses Results: Message Types Predicting Scores on the Five Components of the Peer Evaluation
Proactive vs. Reactive

Students also evaluated proactive participants who posted messages as more important than passive members who only read messages. Table 5 shows the results of regression analysis examining how posting and reading activities predicted peer evaluation results. The results indicate that the frequency of posting predicted the peer evaluation results significantly, whereas the frequency of reading did not. That is, the more frequently a student posted messages, the higher score the student received from peers in their evaluations. However, reading frequency did not contribute to their score in the team project-based learning context.

<table>
<thead>
<tr>
<th>Independent variables</th>
<th>Standardized coefficient</th>
<th>Standard Error</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency of Posting messages</td>
<td>.844</td>
<td>.312</td>
<td>7.305**</td>
</tr>
<tr>
<td>Frequency of Reading messages</td>
<td>.182</td>
<td>.302</td>
<td>.363</td>
</tr>
</tbody>
</table>

Note: Dependent variable is peer evaluation
** p<.01

In individual learning activities, both reading and posting messages have been reported as critical learning achievement factors (Lee, 2008; Fulford & Zhang, 1993). In instructor evaluation, “reading-only” activity as well as “also-posting” activity showed positive effects on academic achievement, especially in individual receptive learning where knowledge reception, rather than critical or creative idea generation, is required more importantly. On the other hand, in team project-based learning, observable proactive participation appeared to be more significant for the students. This difference may be attributed to the interaction-based communal learning context. In individual cognition-based receptive learning, students can acquire knowledge sufficiently well by reading the text alone, without observable participation. In contrast to the receptive learning, the students were required to actively participate in learning activities, leading and participating proactively in interaction-based communal learning. Therefore, for more effective team-based collaborative learning, instruction should be designed to allow students to accurately perceive what constitutes proactive contributions and how to encourage those in addition to self-learning.

Summary and Conclusions

This research sought to determine what components of peer interaction students consider to be important when they evaluate their peers’ contributions in blended team project-based learning. For this research, first, the content-message analysis frameworks outlined in the previous literature were reviewed. Then, because the majority of the previously developed frameworks were not appropriate for coding the contents of the messages collected in this work, an applicable framework for content-message analysis was empirically developed through iterative revision of a customized coding scheme. Three main categories adapted from previous works were elaborated into seven new categories to create a novel message analysis framework. The new framework included the following categories: Intellectual, Informative, Social, Diplomatic, Managerial, Procedural, and Technical. Next, we examined which message categories predicted the peer evaluations. Peer evaluations within each group were measured after two major team projects were completed in one semester. Students were required to post every activity and interaction on their group website; this record enabled teachers to easily track and analyze the students’ activities. A total of 773 messages including 1,814 thematic message units posted by 32 students (eight four-member groups) were categorized using the message analysis framework. In order to determine which categories students use to evaluate their peers, we ran regression analysis to determine what message categorizations predicted the actual peer evaluations that students had given to their peers.

The results showed that the more managerial, procedural, and social messages students posted during the team project-based learning, the higher score they received from the other team members in their peer evaluations. Moreover, students clearly differentiated quantity contributions from quality contributions. Students evaluated informative messages, such as resources or references, as being related to the quantity of the work, whereas intellectual messages, such as an individual’s own ideas, opinions or thoughts, were related to the quality of the work. Although the students perceived intellectual messages as being related to the quality of their teamwork, they valued social and managerial contributions more significantly than cognitive contributions in the comprehensive evaluations.
These results imply that students evaluate their peers on contributions (managerial, procedural, and social) that an instructor would not easily be able to observe. Instructors’ evaluations tend to place a greater emphasis on the outcome or product of teaming rather than on the process of teaming itself (Wang, 2011). Our results thus suggest that controversy regarding the fairness of peer evaluation should not be a matter of credibility or reliability. The difference, if any, between peer and instructor evaluation must instead be based on the differing evaluation criteria. Students’ peer evaluations were considered fair because students perceived each of the different types of contributions clearly, implying that student peer evaluation can be employed as a complementary strategy, especially in communal learning. Students focus on social competencies, such as organizing or coordinating abilities to keep the project moving forward, as important peer contributions. Teachers are unable to deeply access the process of team collaboration, especially when there are many students in a class, although team project-based learning is specifically designed to nurture social competency as well as other intellectual achievements. Therefore, the finding that students can evaluate the social competencies that an instructor cannot readily observe suggests that student peer evaluations constitute a useful, credible, and complementary strategy for instructors in assessing students’ social competencies beyond individual learning competencies. As an instructional strategy to encourage students’ active interaction within each team, teachers could announce at the beginning of the course that peer evaluation results may be included in the final grading.

In addition, the finding that the students who proactively post messages are preferred over reactive and receptive students who only read messages in team project learning indicates that strategies for team project-based learning should differ from strategies for receptive individual learning. Therefore, for more effective instructional design in team project-based learning, instructors should clearly explain in detail what types of participation and contributions are expected in their team project-based learning. Students must be aware of the differences in necessary engagement types between individual receptive learning and communal interactive learning.

Finally, this study highlights the importance of social competencies for a communal society. A report from the Korean Human Resources Research Center (2009) shows how employers’ and professors’ perceptions differ regarding the core competencies that college students should acquire. In the report, employers indicated that social skills (19%) are the most critical abilities for college students to have, followed by attitude (18%), logical thinking skill (15%), leadership (14%), learning ability (12%), creativity (11%), and academic knowledge (11%), whereas professors stated academic knowledge (27%) is the most critical ability for college students to nurture, followed by creativity (27%), attitude (19%), logical thinking skill (13%), leadership (9%), learning ability (3%), and social skill (2%) as the least critical. Another recent news article reported that students at Seoul National University (the top university in Korea) lack group sociability (Yonhap News, 2012); the director of the Career Development Center at SNU stated, “…According to a survey of employers, SNU students show outstanding capabilities in academic knowledge and logical thinking but poor ability in collaboration, interpersonal relationship, and leadership, so how to improve these sociabilities is a critical issue at SNU…” This study contributes to the literature through the novel finding that students do not regard individual cognitive ability to be as critical as managerial, procedural, and social contributions which appear to be more influential in collaborative learning, especially in improving group relations and sustaining group work, unlike in individual learning.

The results and implications of this study show that peer evaluation can facilitate the authentic goal of team project-based learning. The learning goal of team project-based learning is best achieved when teams are effectively collaborating. If one smart student handles most of the team project and produces a high quality end product with little collaboration, it is missing the point of meaningful team project-based learning. In fact, a previous study demonstrates that high-achieving students tend to dominate the team assignment for their good grade, rather than sharing and collaborating socially (Lee et al., 2011). To facilitate collaboration from every student, evaluation of the team working process would be necessary. This study shows peer evaluation can contribute to the process evaluation. Therefore, peer evaluation can be recommended as a useful strategy to encourage and support social competencies, especially in higher education, because the professors are not sufficiently aware of the necessity and significance of social abilities, whereas employers consider sociabilities to be of critical importance.

There are some limitations of this study and suggestions for future research. First, this study is about how students, not instructors, evaluate their peers in team project-based learning. Future work may want to compare the relationships between learning outcome by instructor’s evaluation, peer evaluation, and interaction message types. Second, researchers may want to not only study cognitive learning outcome, but also social learning or acquisition of social skills in team project learning, since they were closely related to the interaction message types and peer
evaluation. Third, this is a case study of one type of course with limited number of students. Researchers should examine additional cases of team project-based learning with broader backgrounds of students before making broad generalizations of the findings in this study.

References


Life Planning by Digital Storytelling in a Primary School in Rural Tanzania

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ABSTRACT

Storytelling is one of the earliest forms of knowledge transfer, and parents often use it for teaching their children values and knowledge. Formal schooling, however, is less inclined to use storytelling as a vehicle for knowledge transfer, and even less as a vehicle for modern self-directed, student-centered, and constructionist pedagogy. Research literature reports experiences on student-centered storytelling in schools, but there is little information about such learning environments using modern information technology. Using a case study approach, we collected qualitative data from a workshop that tested a number of constructionist pedagogical approaches and one-to-one computing technology in a hypercontextualized storytelling workshop. In that workshop, which took place in a Tanzanian primary school, pupils used their XO-1 laptops as digital media tools for expressing their dreams and solutions to overcoming challenges in life. Results of this study suggest that digital storytelling offers additional advantages when compared to traditional storytelling. Designers need to follow six principles for a successful digital storytelling workshop: commitment, contextual grounding, previous exposure to the context, involvement of local experts, atmosphere of trust, and realistic flexible planning.

Keywords

Digital storytelling, Student-centered design, XO-1, One-to-one computing

Introduction

Storytelling is an ancient human activity (Miller, 2008). In many cultures, people use stories to make sense of their world and to pass knowledge on to future generations. Making use of stories in education usually starts already during early childhood, when parents teach their children values and understanding of the world using a language and metaphors that can easily be understood by the child. Educational stories are typically told by the educators in order to convey certain values or information to the learners. In many African cultures oral traditions are current, and promoting growth of the African narratives has been proposed in order to support literacy (Chinweizu & Madubuike, 1983). This study shows how technology can renew the use of storytelling in education, and more surprisingly: in the African context.

The use of stories in education has been found to be most useful in language learning, with emotionally-laden subjects, and for encouraging students to share personal experiences. Woodhouse (2008) listed a number of advantages and disadvantages of storytelling (Table 1).

<table>
<thead>
<tr>
<th>Advantage of storytelling</th>
<th>Disadvantage of storytelling</th>
</tr>
</thead>
<tbody>
<tr>
<td>Students can use storytelling to share stories of success and develop a sense of community</td>
<td>Preparation for storytelling takes time</td>
</tr>
<tr>
<td>Students can use storytelling to explore personal roles and make sense of their lives</td>
<td>Students require a safe environment and may feel uncomfortable to share their stories</td>
</tr>
<tr>
<td>Storytelling enhances creativity, imagination and concentrates the mind</td>
<td>Topics may challenge personal values and therefore be threatening</td>
</tr>
<tr>
<td>The use of imagination enables stories to be remembered</td>
<td>Students may need directions and guidance at various stages of storytelling</td>
</tr>
<tr>
<td>Storytelling enhances critical thinking and listening skills</td>
<td>The students’ response depends on their earlier exposure to storytelling</td>
</tr>
<tr>
<td>Storytelling maintains the oral tradition</td>
<td>Storytelling requires visualization skills and may not suit everyone’s learning style</td>
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We have successfully experimented on digital storytelling methods earlier. Together with secondary school students in Iringa, Tanzania, and the Finnish Evangelic Lutheran Mission FELM, we developed a booklet and an animated digital platform, which were based on students’ real life stories about HIV and AIDS, and we have used that platform for education and counseling of youth in the region and in the country. The platform called “Sura ya UKIMWI” (“the face of AIDS”) has shown to be a useful tool for secondary school students and for counselors working with secondary school students (Duveskog, 2009a), and it won an award in EdMedia 2009 conference (Duveskog, 2009b).

During our work with the Sura ya UKIMWI platform, we learned about the challenges of effective HIV and AIDS education. One aspect that we specifically noted was that efforts to disseminate information on HIV and AIDS lack focus, presence, and personal connection to the issues. HIV and AIDS education is often taught in ways that may have much more contact with medical professionals’ reality than with students’ reality.

Currently research of one-to-one computing (each student has a laptop computer) in developing countries is only emerging (Tedre et al., 2011), there is a lack of literature in digital storytelling, and there is no report of an attempt to combine those two. In order to develop the use of one-to-one computing in storytelling, and in order to develop the contextually relevant aspects of HIV and AIDS education, we developed our digital storytelling approach further and tested it in a workshop that used one-to-one computing as a platform and catalyst for a number of pedagogical changes.

Digital storytelling workshop: Technology as an agent of change

The first change that we tested in our computer-based workshop was the direction of storytelling. Usually teachers tell educational stories to children. We turned the situation the other way round: students were the storytellers and researchers were interested in their stories and in how the story-creating process helps students to develop various skills and insights. The storytelling process was not only individual, but also collective, as students needed to work together to create various parts of the storyline. In general storytelling in groups benefits the participants by offering contextual grounding, bonding individuals, validating and affirming experiences, and educating others (Banks-Wallace, 2007).

To change the direction of storytelling, instead of lecturing to the pupils about HIV and AIDS, the researchers listened to pupils’ feelings and knowledge about the sickness. We used the trigger effect of one-to-one computing (Apiola et al., 2011) to activate students, to break the taboo around HIV and AIDS, and to keep students motivated. Our earlier studies have focused mainly on two aspects of information: gathering vivid personal experiences and delivering information. From the educational technology perspective, in this workshop we wished to explore the ways in which the pupils understood what they learned from HIV and AIDS education, and how they related that information to their own life. We aimed at activating the pupils, observing their activities, and analyzing what kinds of information were understood, misunderstood, mis-delivered, or missing.

Secondly, we adopted a fully digital approach to storytelling. Digital storytelling allows the storyteller to enrich the stories and make them more versatile, exciting, and interesting through the use of text, voice, music, animation, video, and game elements. By utilizing one-to-one computing (XO-1 laptop computers) in the workshop, we promoted digital storytelling experiences through using modern technology to expand traditional narratives. In addition, all the participants experienced what they can achieve with their own basic IT tools.

We used one-to-one computing to facilitate various types of interaction, to store information, to enable access to information, and to enable transfer of information between a diversity of individuals and devices (see Miller, 2008). A digital storytelling study from Egypt showed that as students were able to personalize their experiences, they were able to think more deeply around the topics (Sadik, 2008). In that study students did not only report facts, but reflected on their own thoughts and engagement with the subject—both visually and aurally. Students also practiced reflecting and writing about people, places, events, and problems that characterized their individual life experiences. The study also showed that digital storytelling provided a unique opportunity for students to acquire new media literacy and IT skills (Sadik, 2008). In this research study we analyzed our experiences from digital storytelling on a one-to-one computing platform in a very different context, rural Tanzania, we compared our findings with those of Sadik (2008) and came to the same conclusions.
Thirdly, instead of directly addressing the dire HIV and AIDS problem, we employed an indirect approach that focused on positive aspects of life. Development efforts in developing countries often focus on problems, and by focusing on strengths we wanted to turn that setting the other way round. In this workshop the pupils expressed their hopes and dreams, as well as their ideas about how to use their strengths to pursue those dreams in spite of troubles that may lie ahead. The pupils also planned how to turn challenges into opportunities. Through this kind of approach, we hoped to turn their minds off the immediate problems towards long-term visions. In this workshop, each of the pupils’ dreams was employed as a driving force, and the HIV and AIDS epidemic was one of the challenges to be overcome.

Research context

Iringa is a rural town in the Southern Highlands of Tanzania, 500km inland from the country’s economic hub Dar es Salaam. As a part of their studies, IT (Information Technology) students at Tumaini University in Iringa entered in 2008 a competitive call for projects by the One Laptop per Child (OLPC) foundation. One of the students’ projects got selected by the OLPC Foundation, and 100 XO-1 computers were donated to Ukombozi primary school for an educational project run by Tumaini’s IT students. Currently Ukombozi Primary School is well known nationally, from general public to the ministry level, for its one-to-one computing initiative. There are hardly any primary schools in Tanzania with computers readily available for students, so the case of Ukombozi is interesting from a pioneering educational technology research perspective, too.

Methodology and research design

There is quite some experience on games and storytelling workshops (Fullerton et al., 2004, Miller, 2008, Bers & Cassell, 1998). In addition, there is experience on the use of one-to-one computing in developing countries (Pal et al., 2009). However, the combination of a hypercontextualized storytelling workshop and one-to-one computing in Africa has not been reported in research literature. Of course, due to their contextual specificity, hypercontextualized solutions are not aimed at mass markets, but at a narrow, specialized market segment. One of the main characteristics of the hypercontextualized game concept is that the game is rooted in the specific context where it is going to be played (Islas Sedano et al., 2010). Similarly, the resources available on-site are employed in the workshop’s design and development.

Our long-term project is concerned with three main aims: developing computer aided HIV and AIDS education, increasing pupils’ knowledge and skills in ICT, and coaching pupils about life planning. In this exploratory study we used the school’s resources (e.g., XO-1 laptops, educational materials, teaching staff input) to explore the suitability and sustainability of a hypercontextualized storytelling workshop using one-to-one computing at Ukombozi primary school. Our first research question was, “What kinds of advantages and disadvantages has digital storytelling compared to traditional storytelling?” We used Woodhouse’s (2008) list of advantages and disadvantages of storytelling to analyze the digital storytelling workshop at Ukombozi primary school. That is, we wanted to identify whether the reported advantages and disadvantages of storytelling remain the same when storytelling is taken onto a digital platform.

In terms of educational technology, we especially explored three things. First, we investigated the ways in which the XO-1 works as a tool of expression and self-reflection for building skills for life planning. Secondly, we analyzed the processes through which inexperienced, young ICT users share their knowledge by using XO-1 as a tool. Thirdly, we observed how pupil groups adopted ICT as a planning tool for overcoming barriers in their life (Fig. 1). In order to deepen our understanding of the situation, prior to the workshop we gained knowledge of the participants by interviewing them. We asked them about their background, skills, expectations, and dreams.

Yin (1984) suggests that when the boundaries between the context and the phenomenon of a study are not clearly evident, the use of a case study research method will support one to gain understanding of the complexity of the study, as it helps one to examine contemporary real life situations. Due to the exploratory nature of our research, our research strategy was based on the case study method (Yin, 1984). We followed a qualitative data collection mainly through observations (field work diaries) and log files (video, text, and pictures made by pupils) (e.g., Burrell & Morgan, 1979).
We emphasized gaining first-hand experiences on the participants’ behavior both individually and as a group (Randolph, 2008). Typical of educational research (Cohen & Morrison, 2000), we were active participants in the workshop: We worked with the children, we guided and helped them, and we made observations of their activities. The observational method keeps the researcher sensitive to the contextual richness of the research situation (Randolph, 2008). The observational method has been argued to be especially important where the sequences of events, rather than single events, are of interest (Frechtling et al., 2002). The observational setting in this study was an obtrusive one, as the workshop participants and assisting teachers knew that they were being monitored (Bernard, 1995). However, an unobtrusive approach would have been difficult to be arranged in this research context, where the facilities and infrastructure are lacking, equipment and material are scarce, and the availability of tools and equipment is minimal.

There were 17 participants in the workshops; all the participants were pupils of Ukombozi Primary School and were aged between 11 and 15 years. In addition, there were two researchers facilitating the workshop, three university students from a nearby university, one of the schoolteachers, and the school headmaster. While monitoring the children’s actions and behavior, specific attention was paid to their attitudes and their expressions of feelings towards the topics, to their group dynamics and interactions, and to their shared understandings of the topics.

After a day of individual interviews with the pupils, the workshop started with cycles that each worked through seven stages (Fig. 2). Each cycle started when the facilitators (researchers, assisting teachers, and students from Tumaini University) gave the pupils a challenge that they may encounter in their life. The facilitators prepared the challenges before the sessions, and they were based on themes familiar from the literature and from pupils’ interviews. Next, the pupils prepared their strategies for solving those challenges by individually writing a short text file. Pupils proceeded to discuss their strategies together, and they selected, in groups, a number of strategies as a
point of continuation. Pupils prepared a drama on the topic and recorded their drama using their computers. The facilitators collected the pupils’ video clips and used them later to produce a compilation video. After the pupils had recorded their drama pieces, they proceeded to make illustrations. The text files and illustrations were also collected to be used in the final web application and as research data. From there, we proceeded back to step one by giving the pupils a new challenge (Fig. 2).

Through the workshop, the headmaster of the school supported all our activities, and was interested in the pupils’ performance. A teacher of the school joined each workshop day, mainly in a role of observer and learner. He introduced us to textbooks used at the school. Additionally, the teacher helped with communication between pupils and the researchers. However, the Tumaini University students were the main communication bridge between researchers and pupils. Therefore, the workshop’s schedule was agreed between Tumaini University students, the headmaster, and researchers to assure that the students and pupils were present. The headmaster also informed the pupils’ parents about the workshop before it started, and they were invited to a “graduation ceremony,” where the children presented their work. During each stage of the workshop, either a teacher from the school or the headmaster of the school was involved in planning and translating the challenges. In addition, they observed how the XO-1 laptops were used for integration with other curriculum material.

**Analysis**

Before the workshop started, the pupils were individually interviewed. We asked them about their hobbies, XO-1 knowledge, their preferred software, and finally we asked them about their life dreams. The pupils’ dreams consisted mostly of occupations: becoming a doctor, pilot, journalist, teacher, professor, soldier, engineer, businessman, nurse, lawyer, and priest. This information was crucial for designing a meaningful workshop in line with the pupils’ own interests and ambitions. After this part, the overall work process worked through iterative cycles of challenges (see Fig. 3).

![Figure 3. Digital Storytelling Process in the Workshop](image)

**Challenge 1: Failing studies**

The first challenge in the workshop arose from the tension between the children’s dreams and challenges in life, and the socio-economic environment of Tanzania. The first challenge concerned difficulties in school: “You are failing your studies. What will you do to make sure you can still reach your goals?” The problems that children may face are concerned with the exclusivity of the schooling system, that children may need to repeat a year, that their parents may not be willing to invest in school fees if the child is not doing well in school, and that secondary and tertiary education are only accessible to well-performing and well-off pupils. Pupils discussed their strategies together and expressed their strategies in drawings and text made with the XO-1 computers; they selected strategies for a drama play; they video recorded the drama plays with their laptops; and they displayed the videos using their laptops.
Pupils came up with three kinds of strategies (Fig. 4). The most popular were various forms of escape strategies: Half of the pupils believed that the higher-quality education of private schools would help their study performance. However, as private schools require additional funding, the children planned that in order to secure funding, they would use the church, radio, and the Internet for getting in contact with possible sponsors, such as organizations and famous people. The second strategy type relied on the children’s own efforts: studying harder, but also working harder at home so that the parents would be more willing to continue to support their studies. The third approach was a sort of outsourcing of the problem; either to a higher power or to a possible financial sponsor for studies.

**Challenge 2: Resources and the learning environment**

The next challenge was based on a typical situation in Tanzania: Those pupils who complete primary school need to find a good secondary school. Thus, the next big obstacle concerns the learning environment and funding. We hypothesized a quite common situation where the children’s caretaker becomes sick and children need to acquire their own funding: “What would be the criteria for selecting a good school for you and how will you find funding?” The concern about losing one’s caretaker is very real in Tanzania, and many children already live with adults other than their biological parents. In terms of school quality, children considered private institutions to be superior to government schools. They came up with ten quality concerns, which can roughly be grouped to five groups (Fig. 4).

In Figure 5, teachers and books stood out as the most important single factors of school quality. Regarding quality of teachers, children mentioned, for example, the importance of harmony between pupils and teachers, as well as teachers’ conformance to laws and regulations. Concerning physical prerequisites for education, children considered books to be the most important aspect (as there often is a shortage of books), followed by study material and library.
Regarding physical resources, children considered classrooms to be important: Their current school seats more than 50 pupils per classroom, and often there are not enough seats for each pupil.

Surprisingly, however, none of the pupils mentioned computers or computer laboratories as a criterion for choosing a school. Having 100 laptops at their school, and having an increasing number of Tanzanian schools getting computer laboratories, we expected that children would have included computer labs on their list. But only after the facilitators explicitly raised a question about computers the pupils concluded that computers would also be an important condition.

**Challenge 3: HIV and friendship**

In our earlier work in secondary schools in Iringa, every student we interviewed knew someone who was HIV-positive or who died of AIDS (Duveskog, 2009a, Duveskog, 2009b). In Tanzania HIV affects everyone in one way or another, yet the disease is still a taboo (Duveskog et al., 2003). It is important that pupils find ways of expressing their own thoughts and ideas about HIV in a way that is culturally acceptable. As the issue is highly emotional, specific attention needed to be paid to the formulation of questions and to sensitivity to the reactions and ensuing discussions. In order to protect anonymity and personal identity in the video production, we introduced traditional tribal masks in the plays, and each role in each play was attached to a specific mask instead of a specific child. Those masks allowed pupils to detach their selves from the controversial roles they played, and those masks allowed roles to be carried on even when the actors changed (Fig. 6).

Based on our earlier research and on our current workshop aims, we prepared a number of questions that were aimed at sensitizing the pupils to the issue of HIV in their close circle of acquaintances. The children’s replies indicated that they have talked about HIV and AIDS in school, as the replies showed that they have clear knowledge about transmission, treatment, and stigmatization. Contrary to the common tendency towards stigmatization of HIV and AIDS victims (TACAIDS, 2008), children said that they did not fear if a friend would be infected, and they stated that they would continue to show friendship, care, and support. The children emphasized the role of friendship in giving advice, studying together, motivating each other, and helping each other (in terms of, e.g., school fees, school uniforms, books, and pens). Should a friend turn out to be HIV-positive, children wished to give plenty of advice, but also wished to do things together, such as exercise, help with daily activities, go to hospital, work, and eat together. They wanted to continue to support their friends, and to not ridicule the friend.

Children stated feared stigmatization and isolation in case they turned out to be HIV-positive (it is important to remember that statistically speaking, a number of these children are HIV-positive). Children also expressed that they would feel shame, they would feel like breaking the law, and that people would assume that they have questionable habits. Stigmatization is a big problem in Tanzania and it is one of the main reasons why people do not want to know their HIV status, not to mention revealing their status to others (TACAIDS, 2008). The same concerns worked the
other way too, when children were asked how to treat HIV-positive people. The following dialogue is from one of the drama plays:

J: Masaya, I’m infected
M: Oh! With HIV? When did you go for a test?
J: Today, I just got back from the hospital
M: Oh, I am so sorry to hear that, my friend
J: Thank you, but I need some good advice from you, what do you think I should do?
M: My advice to you, first just seek advice from the doctor, all the problems you have I will help you all the way, just eat good food rich in protein that can build and give your body strength, and use the tablets that will give you a longer life.
J: Thank you, but will our friendship still be there?
M: Oh, of course yes, don’t you worry about that at all.

Challenge 4: Partnership, marriage, and family

All the children except for one, who wanted to become a Catholic priest, wanted to get married and have children. There were a number of reasons that spoke for inclusion of the topic. First, in Tanzania people, especially women, often get married very young; in addition, teenage pregnancies are common. Secondly, the pupils had already received a sound body of knowledge on HIV and marriage, and they already had strong opinions on those issues. Thirdly, there is a view increasingly advocated by educational officers as well as aid workers that starting to talk about reproductive health in secondary school is too late.

The fourth challenge involved a number of common issues in Tanzanian society. As arranged marriages are common, it is important to seek the family’s approval in finding a life partner. Hence, the last challenge involved a case where the pupils’ plans and goals conflict with the ideas of the family. Most of the pupils (9) thought that either they or religious leaders could convince the parents to accept their children’s decisions. Five pupils said they would accept their parents’ decision, while two stated that they would get married regardless of their parents’ view. Going against the will of the family could lead one to a conflict where one might get excluded from the family. When asked about their preferences between partner and studying, none of the pupils was willing to give up their education, as they considered it to be the key for their dreams, and they considered it to be more important than material things even if it led to a break up with the partner.

The last part of the fourth challenge was concerned with the pupils’ opinions about what to do if they found their life partner to be HIV-positive. This scenario involves many controversial and emotional issues. There is the risk of getting infected, the fear of stigmatization, and the uncertainty about the origin of the HIV infection. These issues bring the discussion to a highly personal level and reflect upon marriage and family relations. None of the pupils said that they would leave a HIV-positive partner. However, none of them mentioned that they would take an HIV test to find out their own status. The reasons for not leaving their partners involved oath, love, children, and the fact that leaving would not help the situation. One of the pupils would avoid telling his/her children about his/her positive status, as the children would get sad if they heard that their parents would die.

The richness of the material in all the challenges was a direct result of the use of one-to-one computing where the pupils could feel free to openly express themselves in various ways and it also helped in enhancing their imagination.

Results

In this section we made use of the analysis of the challenges for identifying first how digital technology enhances storytelling and secondly how it neutralizes the disadvantages of traditional storytelling. Woodhouse (2008) listed a number of advantages of traditional storytelling in educational setting (Table 2). We related our analysis to Woodhouse’s (2008) list, and found that digital storytelling offers the same advantages as traditional storytelling does, with a number of additional advantages. Table 2 compares the advantages of traditional storytelling to the advantages of digital storytelling. The left column of Table 2 presents Woodhouse’s (2008) original list of pedagogical advantages of storytelling, and the right column presents the changes brought on by digital storytelling.
Table 2. Traditional storytelling and digital storytelling: Pedagogical advantages

<table>
<thead>
<tr>
<th>Traditional Storytelling (Woodhouse, 2008)</th>
<th>Digital Storytelling</th>
</tr>
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<tbody>
<tr>
<td>Share stories of success and develop a sense of community</td>
<td>Extended community</td>
</tr>
<tr>
<td>Explore personal roles and make sense of their lives</td>
<td>Extended reach of stories</td>
</tr>
<tr>
<td>Storytelling enhances creativity, imagination and concentrates the mind</td>
<td>Increased facilitation of creative processes and focus</td>
</tr>
<tr>
<td>The use of imagination enables stories to be remembered</td>
<td>Extended memory</td>
</tr>
<tr>
<td>Enhances critical thinking and listening skills</td>
<td>Similar to traditional storytelling</td>
</tr>
<tr>
<td>Maintains the oral tradition</td>
<td>Provides a virtual platform for oral tradition</td>
</tr>
</tbody>
</table>

Woodhouse (2008) listed six advantages of storytelling in education. First, he argued that students can use storytelling to share stories of success and develop a sense of community. In our workshop students shared their dreams and strategies to successfully overcome challenges. They were able to learn from each other and link their lives to challenges in their own communities. Students were also able to face challenges in a more positive way and develop a feeling of bringing hope to the community. The digitalized stories enabled the students to share the stories through the web to the global community. In this sense, digital storytelling extended the sharing of stories outside the immediate learning environment, thus extending the reach of their stories.

Secondly, by using storytelling students can explore their personal roles and make sense of their lives (Woodhouse, 2008). In our workshop, students projected their self-image on their future life. They contemplated on their lives in order to overcome typical challenges and eventually live their dreams. Digitalizing the stories did not reduce the component of the students making sense of their lives, but it is unclear if the sense-making was further enhanced by the use of technology. Thirdly, storytelling can enhance creativity and imagination, and concentrate the minds of students (Woodhouse, 2008). In our workshop too the storytelling process encouraged students to be creative, as they had to come up with strategies and imagine the implications of the strategies. Dramatizing the stories and recording their stories with their laptops kept the students focused and facilitated creative processes due to an unfamiliar environment.

Fourthly, in storytelling, the use of imagination enables stories to be remembered (Woodhouse, 2008). Our digital storytelling process involved individual imagination, group imagination, recording, dramatization, and viewing and reflection of the stories. Storing the stories digitally enabled the stories to be viewed at any moment of time, and the stories can potentially be remembered for generations. Fifthly, storytelling enhances critical thinking and listening skills (Woodhouse, 2008). In our workshop, too, students had to critically reflect on how to reach their dreams in life. Digitalizing the stories did not reduce the component of critical thinking, yet it is unclear if technology further enhanced critical thinking either. In the workshop listening skills were not emphasized, as the workshop was more about generating stories than listening to stories.

Sixthly, storytelling maintains the oral tradition (Woodhouse, 2008). Similar, our workshop was based on the oral tradition and maintained the oral tradition. Furthermore, the new technology—digital video recording—provided a virtual platform for the oral tradition and enabled presenting and sharing of the oral tradition in new ways. In addition to Woodhouse’s (2008) list of advantages, we also found three additional advantages. Firstly, apart from being able to store and further share the stories, students also gained additional motivation as their stories could be presented in new ways and for a wider audience. Secondly, students developed their computer literacy skills as a side effect of the life-planning course. Thirdly, a woven story was made, in which the viewer can select the path of continuation of the story.

Woodhouse (2008) listed six disadvantages of storytelling in education (Table 3). First, he argued that storytelling is time-consuming. The same applies to digital storytelling, but digitalizing the stories requires even more time, especially if the students also need to learn new IT tools and applications. Secondly, Woodhouse (2008) argued that students require a safe environment and may feel uncomfortable to share their stories. While sharing stories—especially personal ones—it is important that the students feel safe. In this regard computers work as a neutral platform, as students shared their thoughts more easily with a machine than with a human, as the machine does not
judge or ridicule them. It is important to ensure, however, that if the stories are shared over the Internet, the identity of students must be hidden.

*Table 3. Traditional storytelling and digital storytelling: Disadvantages*

<table>
<thead>
<tr>
<th>Traditional Storytelling (Woodhouse, 2008)</th>
<th>Digital Storytelling</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time in preparation</td>
<td>Initially more time spent to learn new digital tools. Recording and editing add time. Can save time in reuse of material and presentation.</td>
</tr>
<tr>
<td>Students require a safe environment and may feel uncomfortable to share their stories</td>
<td>Neutral platform</td>
</tr>
<tr>
<td>Topics may challenge personal values and therefore be threatening</td>
<td>Impersonal conduit for sensitive topics</td>
</tr>
<tr>
<td>Students may need directions and guidance at various stages of storytelling</td>
<td>New digital tools require additional guidance</td>
</tr>
<tr>
<td>The response may depend on the previous exposure</td>
<td>Similar to traditional storytelling</td>
</tr>
<tr>
<td>Requires visualization skills and may not suit everyone’s learning style</td>
<td>Offers more variety for different talents in visualization</td>
</tr>
</tbody>
</table>

Thirdly, topics in storytelling may challenge personal values and therefore be threatening (Woodhouse, 2008). This applied strongly in our workshop, as it dealt with sensitive topics related to HIV and AIDS. One of the main problems with HIV and AIDS is the stigmatization of people. To reduce the stigma in the society it is, however, essential to challenge personal values, even if it feels uncomfortable to the students. Digital stories are however less threatening than traditional storytelling, as the computer offers an impersonalizing conduit for sensitive topics, and is less intimidating than face-to-face sharing of thoughts. Fourthly, students in storytelling may need directions (Woodhouse, 2008). In our workshop, we used the students’ own lives and dreams as a starting point, and the students had a clear direction, which was working towards achieving their dreams. In general, however, digital storytelling students need additional directions insofar as using digital media for storytelling is a new concept to the students.

Fifthly, the students’ response may depend on their previous exposure (Woodhouse, 2008), and this aspect of storytelling remains the same with digital storytelling, too. Sixthly, storytelling requires visualization skills and may not suit everyone’s learning style (Woodhouse, 2008). In digital storytelling visualization skills are as important as they are in traditional storytelling. Digital storytelling, however, allows the storyteller to visualize stories in various ways, giving more space for different skills. Hence, students are more likely to find a visualization method suitable for him or her. In addition to the disadvantages that Woodhouse (2008) mentions, the impersonalizing nature of digital storytelling may be a hindrance, as stories are highly dependent on their teller.

**Discussion**

**How to design a successful digital storytelling workshops**

The role of design is essential for successful integration of technology into education. According to our observations, the crucial success factors for designing digital storytelling workshop are *commitment*, *contextual grounding*, *previous exposure* to the context, involvement of *local experts* and stakeholders, atmosphere of *trust*, and realistic, *flexible planning*.

First, teachers, headmaster, tutors, facilitators, parents, and children were strongly committed to the workshop and enthusiastic about it. The headmaster was excited and supportive of the workshop goals and the arrangements, and he could see its educational value in terms of English language skills, technological skills, HIV education, and multicultural experiences. Secondly, the workshop was grounded in the local reality and did not rely on ideas alien to the children. Instead, the children wanted to share their reality with the facilitators.

Thirdly, the facilitators had more than ten years of previous experience on conducting similar workshops in developing countries. Thus, there were few surprises about how things can work out. Fourthly, the facilitators
already knew the local OLPC team members. The team met several times every week in order to discuss arrangements, current progress, challenges, and possible solutions.

Fifthly, the involvement and dedication of the local experts, headmaster, school teachers, pupils, and parents created an atmosphere of trust, where the facilitators could trust that things will get done. Often in projects in developing countries facilitators of similar workshops need to put significant amount of time in micromanaging, doing follow-ups, and double-checking that preparations and tasks have been done. Sixthly, the team had a plan to follow, yet that plan was flexible enough to be adapted to the circumstances. Timetables, contents, and technical details were all adaptable to local contingencies.

Motivational factors

One of the big motivators for pupils was the goal that the facilitators will combine the pupils’ products into a storytelling game platform that will be shared within the school as well as in the Internet (available at http://www.cs.joensuu.fi/games/ukombozi/). After each challenge the facilitators displayed a rough compilation of the material in order to encourage the pupils and to demonstrate the technical possibilities. This decision turned out to work well, as the pupils were greatly motivated by their ability to express themselves in various new ways where their work was compiled together for the benefit of others.

The children’s satisfaction and enjoyment with the workshop became apparent over the course of time, as it became habitual that the children would every day run to the facilitators’ car and help to carry equipment into the classroom. Attendance rates were very high (97.6%), even on Saturdays. However, the workshop also created jealousy among those pupils who could not attend the workshop, and might in that sense have created an unmotivating atmosphere among other pupils in the school.

Technical challenges

One-to-one laptops were the quintessential tool for extending storytelling as a pedagogical vehicle. The children loved their XO-1 computers, but the workshop facilitators were more critical about them. While recording video and audio, the built-in microphones of the XO-1 laptops often failed to pick up sound properly, and the image was not always good. The children had to re-take many acts several times, which led them to accidentally learn about environmental effects to digital audio and video. They also used a memory stick to bring their videos to the facilitators.

The pupils’ inexperience with touch pads, as well as the poorly functioning pads as such, caused difficulties to pupils. Hence, drawing pictures became more of a practice and exercise in how to use the laptops for drawing rather than an exercise on drawing things related to the challenge. That is, instead of a tool for self-expression—as the OLPC Foundation would like them to be used—laptops in this mode of working were reduced to basic tools for coping with basics of information technology.

The XO-1 laptops had several unexpected limitations that had to be dealt with (Duveskog et al., 2010). Despite the few deficiencies, the laptops proved to be sufficient for achieving the goals of the workshop, which was based on the idea of using only the available technology.

Conclusion

Digital storytelling offers a number of advantages compared to traditional storytelling. It provides a neutral platform where students feel safer to share their stories even if dealing with sensitive topics. It offers a variety of ways for different talents to express their stories according to their own liking. It increases the motivation for the storytellers. It provides an extended reach of the stories even outside the community where the listener or viewer can learn from the stories. It further enhances creativity, imagination and concentration. It maintains the oral traditions that can be stored for coming generations.
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Enabling Problem Based Learning through Web 2.0 Technologies: PBL 2.0

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ABSTRACT

Advances in Information and Communications Technology (ICT), particularly the so-called Web 2.0, are affecting all aspects of our life: How we communicate, how we shop, how we socialise, how we learn. Facilitating learning through the use of ICT, also known as eLearning, is a vital part of modern educational systems. Established pedagogical strategies, such as Problem Based Learning (PBL), are being adapted for online use in conjunction with modern Web 2.0 technologies and tools. However, even though Web 2.0 and progressive social-networking technologies are automatically associated with ideals such as collaboration, sharing, and active learning, it is also possible to use them in a very conservative, teacher-centred way limiting thus their impact. In this paper, we present PBL 2.0 framework, i.e., a framework combining PBL practices with Web 2.0 technologies. More specifically, we (a) explain the theoretical considerations and construct the PBL 2.0 framework; (b) develop a learning platform to support the PBL 2.0 framework approach; and (c) apply PBL 2.0 in a real-world setting for lecturing University students. Pilot results are encouraging as overall satisfaction with the developed platform and good acceptance of the new learning practices is observed. Although the full potential of PBL 2.0 could not be achieved due to different institutional and cultural obstacles, authors believe that PBL 2.0 framework provides good guidance for designing and implementing a PBL course.

Keywords

Web 2.0, Problem based learning, Collaborative learning, eLearning platform

Introduction

Latest advances in ICT are making an impact in the field of education and training. Social computing and Web 2.0 technologies have brought new and vigorous opportunities for learning (Ala-Mutka et al., 2009) and have realised a shift of Web’s learning role from an information carrier to a facilitator for the creation and distribution of collective knowledge (Maloney, 2007). Technological advances have enhanced the potential of collaborative learning and peer-learning, where learners can become active participants and co-producers of knowledge, thereby providing the opportunity for more horizontal educational structures and contexts (Ryberg et al., 2010a).

Problem Based Learning (PBL) is a learner-centred pedagogy, which pre-dates these technological advances (Jones and Dirckinck-Holmfeld, 2009), but nevertheless incorporates many of the pedagogical ideals that are often associated with Web 2.0 learning. PBL, however, is a multi-faceted pedagogy, which can be organised in a number of ways. Some forms of PBL suggest a more individualised organisation where learners work on their own, whereas others promote a certain level of social organisation among learners e.g., forming loosely coupled learning sets, or more strongly-tied collaborative dependencies such as group work on a common project. Therefore, various technologies and environments have been employed to support such different organisations of PBL (Savin-Baden, 2007). Thus, there can be considerable variance in PBL practices and in the socio-technical solutions developed to support these. This variance is equally pronounced in relation to Web 2.0 learning, which covers a much wider spectrum of diverse and heterogeneous practices, although such differences may not be explicitly explored. In this paper we therefore present conceptual frameworks to differ between various organisations of PBL and different orchestrations of Web 2.0 learning. We call these PBL 2.0 framework, and while it enables the development of multiple pedagogical designs and collaborative dependencies, it also invites practitioners to be more explicit and reflexive about their design for PBL and Web 2.0 practices.

In this context, the main objective of this paper is to investigate Web 2.0 technologies’ potential for enabling diverse, innovative pedagogies of PBL. To achieve this we follow a three-step approach: First, we study the theoretical
implication of PBL in relation to Web 2.0 social learning and develop a PBL 2.0 framework to underpin our proposition. Then, in the absence of suitable Web 2.0 learning environments, we develop a Web 2.0 platform to support the PBL 2.0 framework. Finally, we apply the theoretical framework and platform in a real-world context at an Enterprise Architecture (EA) course for undergraduate University students.

The rest of this paper commences with related theory, namely PBL and eLearning through Web 2.0 and social collaboration forms, and presentation of PBL 2.0 framework. It then presents the developed platform as an enabling means of theoretical work, and their application at a University course. Finally, we discuss our findings and plans for future work.

**PBL and dimensions of control and power**

PBL is a learner-centred pedagogy focusing on learners’ active and often collaborative production of knowledge through engaging with real world problems or cases. PBL is not one commonly agreed upon concept, but rather encompasses a number of different interpretations and practices (Kolmos and Graaff, 2003; Ryberg et al., 2010b). Nonetheless, there are some general traits; e.g., problems are the starting point for the learning process; learners should build on their own experiences and learn through active engagement with cases or real-world problems. The latter often entails research activities such as empirical investigation and writing, often in collaboration with other learners (Dirckinck-Holmfeld, 2002; Kolmos & Graaff, 2003; Ryberg et al., 2010b; Savery, 2006). The same authors further argue that important aspects in relation to understanding the differences between various PBL practices are: the design of the problem, who formulates the problem, who is responsible for major decisions in relation to the problem solving process (teacher- or participant-directed process). PBL practices can span from teachers handing out a particular problem as part of a lecture, to problem and project based scenarios where learners collaborate for extended time periods to produce a project/report addressing a self-chosen problem. However, these vastly different interpretations or variances among PBL practices are not necessarily made salient in particular course designs or in technologies’ design to support these practices.

One useful way of differing between these different constructions of PBL is to distinguish how control or power is distributed between teachers and learners across three dimensions: the problem, the work process, and the solution (Ryberg et al., 2006, Ryberg et al., 2010b). For example, are learners given a particular problem to solve, or are learners to define the problem on their own? Who manages the work process and decides which theories and methods to employ? Finally, to what degree is the solution open-ended or fixed (are learners expected to come up with a predefined solution to the problem or are they expected to produce new insights and knowledge?). The aforementioned considerations on the dimensions of power and control in PBL are graphically depicted in Figure 1.

\[ \text{Figure 1. Central dimensions of PBL} \]

**eLearning 2.0**

The notion of positioning learners as active and productive in real practices seems to correspond well with many of the ideas and ideals associated with Web 2.0 in learning (e.g., Crook and Harrison, 2008 p. 11; Glud et al., 2010; Ryberg et al., 2010a). However, it is important to distinguish between Web 2.0 as a range of technologies (e.g., blogs, podcasts, wikis) and Web 2.0 as particular practices (e.g., blogging, podcasting, writing collaboratively). We emphasise this distinction because employing a Web 2.0 technology does not necessarily entail pedagogically innovative Web 2.0 practices (Dohn, 2009; Glud et al., 2010), as it is still possible to use Web 2.0 tools in a very conservative, teacher-centred way. For example, a teacher may choose to create a blog, and then use it to disseminate information to learners, not allowing them to write or comment. Therefore, Web 2.0 learning is not only about adopting particular technologies, but equally about the degree to which teachers adopt more learner-centred,
participatory or collaborative practices. Therefore, we argue, we should be careful in ascribing too much power to perceived inert affordances of particular technologies, and focus equally on how technologies are enacted or taken into use by practitioners.

Therefore, adopting Web 2.0 learning includes more or less radical changes in the relations between learners and teachers in terms of power and control over the learning processes and environments. Thus, new tensions and challenges arise. Complementary to the model identifying central dimensions of PBL, we additionally propose another conceptual model. This second model maps the aforementioned tensions specifically in relation to Web 2.0; but also serves as a way of guiding designs for Web 2.0 learning (Buus et al., 2010; Glud et al., 2010, Ryberg et al., 2009; Ryberg et al, 2010b). These tensions can be mapped across four central axes (Figure 2), which practitioners can use to reflect on their design and values.

![Learning Process](image)

**Figure 2. Central dimensions of Web 2.0 learning**

This model provokes questions in relation to who controls the flow of the learning process: Should learners be self-directed, should they decide how to collaborate? Is students’ internal motivation enough or are external motivational factors needed? The notion of “motivation” also addresses potential pitfalls, such as assuming that the “tools” in themselves are motivating e.g., assuming that because students exchange social messages on Facebook, they will equally engage in sharing relevant learning resources as part of a course. Furthermore, one can ask who controls the technical infrastructure, decides which Web 2.0 tools/practices to use, and decides what can be posted, shared and produced. Will the teacher be the main provider of resources and content or will learners provide and share relevant material as well?

**New forms of collaboration**

A very interesting aspect of Web 2.0 developments is that they enable new social constellations or levels of social aggregation. Dron and Anderson (2007) point to three levels or types of social aggregation: The group, the network and the collective, with the learner placed in the centre (Figure 3).

**Groups** are tightly knit social constellations often mutually engaged in working with a common problem, project or task, whereas **networks** entail fleeting membership structures and boundaries; individuals can move more freely in and out of networks. Networks are emergent rather than designed and do not necessarily revolve around a particular task, although they could also be thought of as a “class of students” or “semester” (Dalsgaard, 2006). Networks often build upon shared interests, e.g., resources, bookmarks, websites, articles, material etc., which is of interest to oneself and potentially also to fellow students or other network members. Finally, the **collective** has an even looser and emergent structure with no sense of conscious membership or belonging. Collectives are aggregations of individuals’ uncoordinated actions from which e.g., tag-clouds, recommendation systems or page-ranking systems emerge (Dron & Anderson, 2007).

Web 2.0 technologies have amplified and rendered the latter two levels of social aggregation visible through social networking technologies and systems building on the mass-aggregation of individual actions (e.g., Digg.com, tag clouds or various recommendation systems). We view this as an emerging re-conceptualisation of the role and form of online educational systems in relation to how they support collaboration between learners and teachers, and how they offer connections to various external resources or resource persons. This is strongly pronounced in current trends of moving the focus from Virtual Learning Environments, where the teacher organises the tools and structures the dialogue (Crook et al., 2008, p. 36), towards Personal Learning Environments, where learners customise their own learning environment (Attwell, 2007, p. 1; Conole et al., 2008).
PBL 2.0

As outlined previously terms such as Web 2.0 learning or PBL cover a diverse set of learning practices and vastly different pedagogical designs. Adopting “new,” “innovative” technologies can often gloss over the fact that while new tools have been adopted the underlying structures of control have not been changed. However, when adopting new practices and roles it might be difficult to identify what tensions and contradictions might arise from such changes. The contribution of the conceptual PBL 2.0 framework is to enable practitioners to critically reflect on their own pedagogical designs, and be more explicitly aware about central values and tensions when employing PBL and Web 2.0 learning approaches. The aim is not to argue for a particular interpretation of what constitutes a “real” PBL design or a “true” Web 2.0 approach. Rather, providing practitioners with conceptual tools to reflexively and critically engage in designing innovative PBL pedagogies better reflect the landscape of varied practices that evidently exist within education today. Asking critical questions about dimensions of power and control between students and teachers, e.g., in terms of working processes and ownership of tools and resources, can furthermore help in developing or adopting learning technologies suited for particular purposes, or technologies that are sufficiently diverse to serve different purposes, e.g., both more teacher-driven and learner-driven activities, or closely-tied collaboration in groups as well as more loosely-tied interactions and exchanges within a larger network.

Platform implementation

Moving from theory to practice, we sought for an appropriate tool and came across a number of free online tools such as Elgg (Elgg.org) and Mahara (Mahara.org). However, we were not able to find a solution to fit all of our PBL 2.0 propositions. We therefore decided to base our practical implementation on a proprietary solution and expand it to fit our purposes.

We mainly targeted enhanced collaboration opportunities and flexibility at the teacher-learner continua, so the following functionality is included in the proposed platform:

- Use of popular Web 2.0 tools, e.g., blog, wiki, forum.
- Integration of existing standards, e.g., SCORM.
- Division of collaboration space into three embedded scopes, i.e., Class Desk, Group Desk, My Desk.
- Organisation of resources, based on scopes.
- Improved identification and searchability of resources, based on tagging, rating, and commenting system.
- Back office facility to support facilitator/teacher role.

There are four workspaces in the platform:
• *My Desk* is a workspace personal to a user. Here, he/she accesses all files, links, messages that have been shared solely with him/her.

• *Group Desk* is a workspace personal to a group. A user assigned to a group sees all files, bookmarks, messages that have been shared with his/her group, and accesses group’s collaboration tools (e.g., wiki, forum).

• *Class Desk* is a workspace common to the entire class. Here, the user sees all files, bookmarks, and messages that have been shared with the class, and accesses class’ collaboration tools (e.g., wiki, forum).

• *BackOffice* is a workspace accessed only by the teacher/facilitator. Here, he/she sees an overview of all courses, classes, students, groups, etc.

Using the workspace menu (Figure 4) a user can navigate to any workspace. Workspaces contain the actual content, whereas the notification panel on the homepage only contains notification feed about all platform activity. The faceted menu in the left sidebar displays a subset of all content or notifications, and the sharing panel is used for posting of user’s statuses/comments.

*Figure 4. Platform Homepage*

Regarding the central dimensions of PBL (*Figure 1*), the *problem*, the *work process* and the *solution*, the proposed platform can facilitate both a more teacher-controlled and a more learner-controlled approach for each of the three dimensions. While there are two distinct user roles: the *learner* role, who registers to the platform to collaborate with other members and have access to shared resources, and the *teacher* role, who is the facilitator of the platform and has an overview of all learner activity; the amount of freedom and control that learners have is decided on by the teacher role. Whether the teacher or the learner is defining the problem, work process, and solution, the same tools and functionality are available to the learners. Furthermore, the teacher/learner roles are not restricted explicitly to actual learners/teachers; even an actual learner could undertake teacher’s role in a highly learner-controlled learning setting. For example, any approach to the problem dimension is supported by the platform: The teacher can simply announce the problem to the students by using the platform (fully teacher-controlled), or learners can collaboratively decide the problem e.g., by using wikis and sharing relevant resources (fully learner-controlled), or any other compromise between these two extremes. Similarly, the work process could be defined by the teacher, the learners or both. As regards the solution dimension, we recognise that the decision whether one fixed or open-ended solution
will be accepted is independent of the platform. Nevertheless, the platform still offers learners a wide range of tools for the solution’s collaborative construction and presentation.

In relation to teacher/learner tensions in Web 2.0 learning (Figure 2), the proposed platform can again facilitate both a more teacher-controlled and a more learner-controlled approach for each of the four dimensions. The implemented Web 2.0 tools and facilities, such as blogs, wikis and forums as well as sharing, tagging, and rating of resources, allow for a wide range of control in learning process, infrastructure and resources dimensions. Notwithstanding however the fact explained previously that the provision of a range of Web 2.0 technologies does not necessarily entail pedagogically innovative Web 2.0 practices. For example, regarding the learning process the social character and tools of the platform allow for full learner control but also for directed teacher-to-learner control if needed. Regarding the technical infrastructure, learners and teacher have the same degree of flexibility for using the offered tools and they can select to rate, tag, post either to their group or to the whole class; thus there are no limits to the way the infrastructure can be utilised. As far as resources/content are concerned, the platform makes it possible for both teachers and learners to upload, share, tag, bookmark, retrieve, rate resources, etc.; thus it allows for any kind of mix of teacher and learner control. Regarding the motivation dimension, we recognise that this is something more intrinsic and that it cannot be claimed that a technological solution is able or not to facilitate this. Of course, there is a chance that the social character of the platform maximises users’ interest; however this is not always the case for eLearning platforms, as opposed to entertaining platforms like Facebook and Twitter, and it depends on many imponderable factors (such as the educational setting, the bonding between learners, learners’ character and behaviour, etc.) whose further exploration is outside the scope of this paper.

The platform supports personalisation but it also enables multiple connections between people and resources at different levels of social aggregation (Figure 5). While the platform could be used for internal communication and collaboration for a group of learners, e.g., a group working on a class project, it could equally act as a common space for a network of learners, e.g., students within the same class, or it could even act as a support community for a collective of learners, e.g., all students that attended the same class over current and past years/semesters. The level of the collective is thus supported in the sense that imported resources, shared bookmarks, tags, ratings, etc. remain in the database even after the class is finished; thus, new learners that attend the class can make use of the aggregated “knowledge” of their peers and further build on it for the learners to come.

![Levels of social aggregation in the proposed platform](image)

Figure 5. Levels of social aggregation in the proposed platform

While the developed platform in many ways resembles other popular tools for development of PLEs, such as Elgg or Mahara, the functionality of Class Desk and BackOffice distinguishes the developed platform from these systems. For example, in Elgg there are only ”groups/communities“ (Group Desk) or “individual profiles“ (somewhat similar to My Desk), whereas the level of aggregation of a Class with the associated specific tools for this scope is not present. Likewise, there are no particular tools for teachers such as the BackOffice (only an administrator’s area which does not have particular functionality for “teachers”). The same is to some extent true for Mahara, although in Mahara people can be grouped into “institutions,” which can mimic some aspects of belonging to a class or semester, but without the same level of functionality (shared tools like wikis and forums, overview of classes/courses and opportunities for grading).
While the notion of grouping learners into manageable,gradable “classrooms” may seem to run counter to some of the intentions of PLEs and Web 2.0 practices, this functionality first of all reflects the reality of most universities, schools and training institutions, and furthermore it might be an enabler in terms of supporting increased transparency at the level of a network or a collective. Experiences with Elgg and Mahara at Aalborg University (Ryberg et al., 2010a; Ryberg & Wentzer, 2011) suggest that it can be difficult to enable sharing of resources at these levels. This for one thing has to do with the pedagogical and technological scaffolding of these activities. They show that caution should be exercised in assuming that students possess advanced skills in relation to social software technologies, and that they can unproblematically “translate” experiences from using similar tools within informal contexts (e.g., Facebook or Twitter) into making good academic use of social software technologies for their own and others’ learning (Ryberg et al., 2010a). Although a “status-update” field in a learning platform may structurally be the same as on a social network site the field of relevant activities might be different (socialisation vs. sharing of resources and collective learning). However, this might also have to do with uncertainties of whom one is sharing with (e.g., if the system spans users from different semesters or even different programmes). In this sense having an aggregate of a class or semester might resonate better with students’ experience and need for having a meaningful social context.

Elaborating at a more technical level, the developed platform is based on MVC (Model-View-Controller Model) software architecture pattern. Figure 6 presents the platform’s deployment diagram using the Unified Modelling Language (UML); platform is hosted on an Apache2 web server, running the Debian OS. The PASTE Python WebServer is the application server used, as the platform is written in the Python programming language. MySQL is used as the database management system.

**Figure 6. UML deployment diagram**

**Pilot application**

The aforementioned learning considerations are particularly relevant to lifelong education and training of multidisciplinary topics, such as Enterprise Architecture (EA). Since its introduction by Zachman (1987), EA is gaining increased recognition worldwide (IFEAD, 2005). However, EA is a topic in need of deep and diverse background competencies (technical, business, organisation-specific competencies as well as enhanced personal and communication skills, see Tambouris et al., 2009) that are often acquired within a collaborative PBL context. Therefore, EA is the topic selected for piloting the aforementioned theoretical work and the proposed platform.

Four pilots have been performed in different settings and countries, involving three stakeholder groups: University students, private employees and public servants. We decided to elaborate on one of these pilots, the one involving University students, due to space limitations, results’ similarity and the fact that this pilot redesigned a pre-existing course. The pilot was carried out at the University of Macedonia, during the spring semester 2010 targeting the
students of the “Enterprise Architecture” course for the degree of Technology Management. The course is taught in the fifth semester of an eight-semester curriculum, and aims at presenting a holistic framework of managerial analysis and modelling, which unifies technological with managerial aspects of an organisation. The course is attended by IT literate students in their early twenties without previous working experience.

In this pilot we applied new PBL practices with enhanced student control compared to the usual University practice. However, there have been certain restrictions to our degree of freedom to apply radical changes due to the nature of the pilot, e.g., being part of an academic degree-awarding curriculum. Specifically, the course could not be organised solely as an eLearning course, it had to have physical attendance for a three-hour lecture every week and it had to have a mandatory written exam at the end of the semester which would count for the majority of the awarded course credits. Moreover, the basic background knowledge and lack of professional experience of undergraduate students is another restrictive factor for enhanced learner-control especially in highly complex topics as EA. Nonetheless, the academic course could still benefit from the PBL 2.0 approach so that students could exercise more control in their education, i.e., have the chance for more participation in and out of the classroom and for getting involved in solving EA related problems together with their peers.

For redesigning the University course, we commenced by rethinking the current learning practices and tensions and studying how to apply the new PBL practices and move tensions more on the students’ side. We did this for each part of the course, namely theory, practice and assessment. The high-level structure of the redesigned course is depicted in Figure 7, the blue solid and the brown dashed line depicting the redesigned and original courses respectively. The theoretical content was not much differentiated, although it was now enhanced and also uploaded in the platform. The redesigned course’s practical part was quite differentiated with the inclusion of weekly assignments. In terms of assessment the new feature of group presentation in classroom was also added.

![Figure 7. Pilot course high-level structure](image)

Contrary to the original course design that was fully teacher-controlled, the redesigned course allows for more learner control. This is depicted in the teacher versus learner tensions of Figure 8 with the stripped areas denoting the range of control. We use areas (not points) of control as we want to depict the potential offered to students to exercise more or less control.

The PBL continua show that the theoretical part of the course remains as it was before the redesign; fully controlled by the Professor. This decision was taken due to different limitations such as the strict University curricula, the learners’ elementary level of skills and experience, and the complexity of the EA topic. However, there is large degree of learner control in the practical part of the redesigned course, as students are now able to choose the assignments’ topic and work towards an open-ended solution. As regards the work process, students theoretically are allowed to use any kind of relevant theories and methodologies, realistically however it is expected that students will ground their assignments on the theoretical background and methodologies provided by the Professor during the theoretical part.
Nonetheless, at the Web 2.0 learning continua there is now more control exercised by learners both at the theoretical and at the practical part of the course. Regarding the learning process, there is now more learner control as students can, even in the theoretical part, share, bookmark and tag different relevant resources additionally to the ones provided by the Professor. Moreover, and as regards the practical part, students now have the opportunity to choose the case studies for their assignments, to form their own groups and decide the best way of collaboration within each group. However, the Professor still decides upon the scope, the deadlines and the timing of assignments’ presentation to the class. As regards infrastructure, the Web 2.0 platform is now available providing the same level of control to both Professor and students. The only feature restricted to the teacher role is the assignment of students to groups which has been intentionally kept teacher-controlled for internal organisation purposes (assuring that the selected groups will remain as chosen until the end of the semester in order to efficiently facilitate evaluation of group work). As regards the resources/content dimension, students can now have much more control both in theory and practice. As mentioned previously, the Professor remains the main provider of theoretical resources and content; however students may also participate with own contributions or through rating, commenting, tagging, etc. In the practical part, students can now not only find, add, share, tag, comment resources but also organise resources within My Desk and Group Desk. Finally, as regards motivation, we have no evidence that the redesign can have a significant impact on motivation, since the main motivation for students to commit to this specific course is that it remains a mandatory course for obtaining the University degree.

The pilot’s levels of social aggregation are depicted in Figure 9. At the group level, students now form groups for preparing and delivering their assignments. These groups collaborate within the dedicated Group Desk area of the platform where the final assignments for grading are also uploaded. The network level corresponds to the whole...
class of 2010 spring semester of the EA course. It encompasses an amount of students that may or may not know each other and retains some distinct network characteristics such as shared interest on the course and reputation driver. The collective level corresponds to the total number of students that have taken and will take the EA course at the University of Macedonia and to their Professors; after a few years the platform will have a large amount of aggregated knowledge at students’ disposal.

Pilot evaluation

To evaluate the pilot we performed an assessment of students’ and Professor’s experience. Students provided feedback by anonymously answering an online questionnaire after the course ended, while the Professor provided feedback through a semi-structured interview. Hence, a mixed method of quantitative (students’ survey) and qualitative (Professor’s interview) evaluation was applied.

Students’ evaluation was based on the method proposed by Shee and Wang (2008) for evaluating a web-based e-learning system in a college context. It comprises 4 dimensions: learner interface, learning community, system content and personalisation; however, we disregard the latter as not relevant to our platform. Due to our intention to keep the questionnaire short we selected eight questions assessing the first three dimensions; we also added demographic questions.

Out of 50 registered students we finally gathered 12 answered questionnaires (24%); an adequate response rate considering that non-mandatory presence in University lectures resulted in about 8 students fully attending the course, and that the survey timing was after the semester exams when most students were on summer vacation. Most respondents were male (58%), 25% took the course for the first time, and most respondents were regular course attendants throughout the semester.

Surveyed questions and responses are provided in Table 1. Collected data was processed in SPSS 19 software; reliability was tested using Cronbach’s alpha and validity was tested through confirmatory factor analysis. Table 2 displays the results of the factor analysis showing that responses load to three factors: the first factor corresponds to learning community dimension, the second factor to learner interface dimension and the third factor to system content dimension. Table 3 presents Cronbach’s alpha for each of the dimensions; learner interface and learning community can be considered highly reliable whereas system content reliability is just acceptable.

Table 1. Students’ feedback to questionnaire survey

<table>
<thead>
<tr>
<th>Possible answers</th>
<th>Applies completely</th>
<th>Applies a lot</th>
<th>Applies partly</th>
<th>Applies a little</th>
<th>Does not apply at all</th>
</tr>
</thead>
<tbody>
<tr>
<td>Learner Interface</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>User-friendliness</td>
<td>The navigation and structure is clear and consistent. The needed resources can be found easily</td>
<td>14.29% 42.86% 28.57% 14.29% 0.00%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ease of understanding</td>
<td>The platform provides the functionality expected/known from a learning</td>
<td>14.29% 57.14% 28.57% 0.00% 0.00%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>The didactics applied are understandable</td>
<td>8.33% 66.67% 25.00% 0.00% 0.00%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Material provided online is usable and regarded as good support for the course</td>
<td>8.33% 41.67% 50.00% 0.00% 0.00%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Learning Community</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ease of discussion with other learners</td>
<td>The communication and collaboration means (blogging, email, messaging, chat, forum) provide an applicable environment for collaboration with my co-students</td>
<td>28.57% 28.57% 14.29% 28.57% 0.00%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>The communication and collaboration means (blogging, email, messaging, chat, forum) provide an applicable environment for collaboration with the tutor</td>
<td>28.57% 14.29% 28.57% 14.29% 14.29%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>System Content</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sufficient content</td>
<td>Learner provided sufficient working aids</td>
<td>8.33% 58.33% 33.33% 0.00% 0.00%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Useful content</td>
<td>Content presented is understandable and can be followed</td>
<td>25.00% 33.33% 41.67% 0.00% 0.00%</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

In overall, student feedback has been satisfactory. 71% gave positive answers to whether the platform provides the functionality expected from a learning environment, while only 14% were negatively positioned regarding navigation/structure clarity and easiness of locating resources online. 3 out of 4 students found the applied didactics understandable, and none of the students has a negative opinion on the online material. Regarding the provided content 2 out of 3 students found it sufficient and 58% found it understandable. In average, students have a positive
opinion of collaboration facilities; however collaboration/communication opportunities with the Professor is not that highly assessed as with the co-students. We thus assume that students would prefer some extra communication channel with the tutor than plainly utilising the same channels and means as with their peers. However, this seems to be in a way against the notion of moving towards the learner-controlled side of PBL; therefore we may conclude that students were hesitant to fully work under an environment of high learner control—maybe there is some inertia involved when moving from the teacher-controlled to the learner-control side of the model.

Table 2. Factor analysis output

<table>
<thead>
<tr>
<th>Component</th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>The navigation and structure is clear and consistent. The needed resources can be found easily.</td>
<td>-0.232</td>
<td>0.873</td>
<td>0.032</td>
</tr>
<tr>
<td>The platform provides the functionality expected/known from a learning environment</td>
<td>-0.606</td>
<td>0.610</td>
<td>0.190</td>
</tr>
<tr>
<td>The didactics applied are understandable</td>
<td>0.371</td>
<td>0.667</td>
<td>0.322</td>
</tr>
<tr>
<td>Material applied online is usable and perceived as good support for the course</td>
<td>0.307</td>
<td>0.820</td>
<td>0.262</td>
</tr>
<tr>
<td>The communication and collaboration means (blogging, email, messaging, chat, forum) provide a applicable environment for collaboration with my co-students</td>
<td>0.885</td>
<td>0.009</td>
<td>-0.329</td>
</tr>
<tr>
<td>The communication and collaboration means (blogging, email, messaging, chat, forum) provide a applicable environment for collaboration with the tutor</td>
<td>0.933</td>
<td>0.152</td>
<td>-0.176</td>
</tr>
<tr>
<td>The lecturer did provide sufficient working aids</td>
<td>-0.218</td>
<td>-0.106</td>
<td>0.728</td>
</tr>
<tr>
<td>The content presented by the lecturer is understandable and can be followed</td>
<td>-0.187</td>
<td>0.170</td>
<td>0.867</td>
</tr>
</tbody>
</table>

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
a. Rotation converged in 5 iterations.

Table 3. Reliability analysis per criterion

<table>
<thead>
<tr>
<th>Reliability Statistics</th>
<th>Cronbach’s Alpha</th>
<th>N of Items</th>
</tr>
</thead>
<tbody>
<tr>
<td>Learner Interface</td>
<td>0.817</td>
<td>4</td>
</tr>
<tr>
<td>Learning Community</td>
<td>0.968</td>
<td>2</td>
</tr>
<tr>
<td>System Content</td>
<td>0.591</td>
<td>2</td>
</tr>
</tbody>
</table>

Sample questions for Professor’s interview referred to four dimensions: competence development, learning methodology, content and technologies. The semi-structured nature of Professor’s interview enabled us to draw more qualitative conclusions as well as to shed more light into students’ responses. The main conclusions from Professor’s evaluation are as follows.

- When left free to choose the assignment case topic, students showed difficulty handling this option. They clearly felt more comfortable when provided with a pre-defined case from their Professor. The case finally proposed by Professor was in eProcurement, an area that proved difficult for students to follow; they could easily remain in a superficial description but could only with difficulty go deeper as the required domain knowledge proved to be too technical and complicated for undergraduate students.
Regarding students’ interaction with the online content, students did not really interact with theoretical content; assignments were the main “experimental” playground for students mostly for downloading/uploading relevant material. However, students’ online communication has been limited since students met anyway at the campus. Thus, students preferred physical face-to-face contact instead of a purely online collaborative model. Due to this, each group usually used a proxy-person to perform most online activities and upload the group assignment.

Professor reported that PBL 2.0 methodology is very powerful and appropriate for university courses. However, it assumes a certain level of students’ maturity which is not always in place (depending of course of students’ general standards and accustomed way of working). Overall, it seems that good students like a lot this way of working while weak students cannot easily meet such expectations.

Rest pilots reported similar evaluation results. Additional comments include the wish for more interactive content (e.g., multimedia), more concrete examples and case studies and the implementation of additional Web 2.0 services. Detailed pilot results are publicly available in the relevant project deliverable (removed to ensure authors’ anonymity).

**Discussion and conclusions**

PBL is a learner-centred pedagogy that has been discussed for decades among the education and learning community. Although at a first glance PBL seems like a simple approach to implement, our involvement in practically applying it at a University setting proved the theoretic notions that there is a wide range of possible interpretations. The approach finally decided has been largely influenced by the discussed institutional restrictions, incorporating nevertheless many PBL characteristics, such as: Learners are empowered to actively engage in the course and build on the collective knowledge/experience of the group/class/collective; a case (problem) is the starting point of students’ assignments; this case is self-chosen and without a pre-determined solution; group assignments allow enhanced freedom for further investigation, collaboration and decision-making within a group context. At the same time, the pilot application managed through the utilisation of the proposed Web 2.0 platform to incorporate the eLearning 2.0 propositions. Focus has been shifted to the learners empowering them to become more active, collaborative and productive, by producing sustainable knowledge rather than only consuming. Moreover, through the overall redesign of the course attention was shifted from Web 2.0 tools to Web 2.0 practices, e.g., how the platform tools would serve the PBL learning approaches decided.

However, the overarching question is whether and to what extent the pilot application was successful. This question comes with no clear, straightforward answer. On the one hand, the pilot application may be considered a success due to the evidence provided by the course evaluation. The redesigned course has been executed smoothly and the new learning practices have been accepted effortlessly by the students. Students also seem satisfied from the platform, its user-friendliness and the means of communication and collaboration. On the other hand, the full potential of PBL 2.0 could not be reached as students did not fully exploit all opportunities resulting from the control shift towards the learner side of the continua. Moreover, students were not that active online as it was expected; they did not contribute many resources and they preferred face-to-face collaboration for their group assignments.

The overall conclusion is that PBL practices may be enhanced by the usage of Web 2.0 tools. The proposed PBL 2.0 framework provides good guidance to anyone trying to design and implement such a course. Moreover, the proposed Web 2.0 platform has the potential to facilitate learning settings implementing PBL 2.0 practices. Nevertheless, there are certain criteria and restrictions to be considered when designing such a course. Our pilot application enabled us to recognise such issues relevant to institutional/organisational requirements and cultural barriers, such as resistance to change and difficulty to adapt to new ways of working.

Our plans for future work span towards two directions; enhancing the Web 2.0 platform with new features and applying the PBL 2.0 framework in different learning contexts. Ideas for further enhancing the platform refer to the back office facilities and to integrating semantic technologies and algorithms for dynamically analysing connections between individuals and groups (e.g., to be able to suggest resources your group mates have visited or bookmarked). Furthermore, we are planning to further pilot test the framework in different educational and training environments with different goals and limitations. Examples of different pilot settings include different levels of education (e.g., graduate or summer courses), different training sessions and seminars within an organisational context (e.g., employees’ development courses within an enterprise), etc.
Acknowledgements

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References


An Electronic Library-based Learning Environment for Supporting Web-based Problem-Solving Activities

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ABSTRACT

This study aims to develop an electronic library-based learning environment to support teachers in developing web-based problem-solving activities and analyzing the online problem-solving behaviors of students. Two experiments were performed in this study. In study 1, an experiment on 103 elementary and high school teachers (the learning activity designers) has been conducted to understand their views toward an electronic library-based learning environment. The results showed that with this innovative approach, electronic libraries not only have the potential to support traditional in-class learning, but also can assist teachers in developing learning activities for training students in web-based problem-solving abilities. Moreover, teachers of different ages and backgrounds all readily accepted the new approach, in particular, the older and more experienced teachers showed even higher willingness to use the system than the younger and less experienced teachers. In study 2, a quasi-experiment on 62 elementary school students (experimental group with 31 students and control group with 31 students) has been undertaken on a natural science course for evaluating the effectiveness of the proposed approach. Experimental results showed that this innovative approach can improve the students’ learning achievements and attitudes in comparisons with the conventional web-based learning approach.

Keywords

Web-based learning, Problem-solving, Learning portfolio, Electronic library, Computer-assisted assessment

Background and motivation

The rapid growth of digital resources has encouraged the development of digital archives for various purposes. One of the most important roles of digital archives is to serve as learning material providers for the learning activities conducted in all levels of schools (Boumarafi, 2010; Chen, 2010; Chu, Hwang, & Tseng, 2010; Hall & Davison, 2007). In the past decade, many studies concerning the use of digital archives in education have been reported (Chiou, Tseng, Hwang, & Heller, 2010); for example, Chu, Hwang, Huang and Wu (2008) developed an electronic library to support outdoor learning for an elementary school natural science course.

While trying to find better ways of using digital resources in education, educators have recognized the importance of training students in the competence of collecting and using information for problem solving. Various studies have been conducted to investigate this issue, including the development of learning strategies or tools to support web-based problem-solving activities (Hwang, Tsai, Tsai, & Tseng, 2008; Skylar, Higgins, & Boone, 2007; Tseng, Hwang, Tsai, & Tsai, 2009), investigations of the learning behaviors and performance of students using web-based information for solving problems (Allan & Street, 2007; Tsai, Tsai, & Hwang, 2011), and the development of subject content-related digital archives for supporting problem-solving activities (Chen & Chen, 2010; Wang & Hannafin, 2009).

One of the major difficulties of using digital resources in learning activities is the lack of an easy-to-follow procedure for inexperienced teachers to design subject content such that suitable digital archives or technologies can be properly applied to the learning process (Chu et al., 2008; Hwang, Chu, Lin, & Tsai, 2011; Hwang, Kuo, Yin, & Chuang, 2010), in particular, problem-solving activities. Therefore, it has become an important but challenging issue to develop a learning environment to assist the teachers in using electronic libraries to develop web-based problem-solving activities.
Based upon these perspectives, in this paper, an electronic library-oriented learning environment for supporting web-based problem-solving is presented, which provides an innovative approach to guiding teachers to systematically and efficiently design web-based problem-solving activities with electronic libraries. The feedback of the teachers who have experienced the proposed learning environment is collected to evaluate the usefulness of this innovative approach; moreover, an experiment has been conducted on an elementary school natural science learning activity to compare the learning performance of the students who learned with the proposed approach and that of the students who learned with conventional web-based learning approach.

Literature review

Electronic libraries have been recognized as being important resources and facilities for supporting educational activities (Saeed, 2006). The rapid advance and popularity of the World Wide Web have further enabled people to conduct web-based learning activities with electronic libraries (Mourad et al., 2005; Polly & Ausband, 2009). Nowadays, electronic libraries play an important role in library service. Various studies have been conducted to develop new information technologies to provide more efficient and effective library services (Uzoka & Ilatuyi 2005). Meanwhile, the number of Internet users is increasing at a dramatic speed; therefore, it has become an important issue to develop effective mechanisms for helping students utilize electronic libraries on the Internet (Saeed, 2006; Chu et al., 2008).

Among the existing alternatives for web-based learning, the development of a web-based problem-solving activity is one of the most crucial and challenging issues for teachers. Web-based problem solving refers to learning activities which engage students in utilizing digital information in an organized and meaningful manner. In a web-based problem solving activity, the students are asked to collect data from the Internet using search engines in order to answer questions raised by the teachers, or to state their opinions about a particular issue (Polly & Ausband, 2009).

Many researchers have reported the effectiveness of web-based problem-solving approaches. Kanuka, Rourke and Laflamme (2007) found several advantages of such an approach, including providing the opportunity to structure the collected information, and allocating clearly defined roles and responsibilities for the students. Zheng, Perez, Williamson and Flygare (2008) further investigated the perceptions of teachers regarding the use of web-based problem-solving strategies, and received positive feedback. It can be seen that guiding the students to learn to solve problems via searching for information from digital resources has become an important and challenging issue. These studies not only demonstrate the importance of providing new electronic library services in education, but also show the necessity of developing new facilities to help teachers develop web-based problem-solving activities that will enable the students to solve problems by searching for information from electronic libraries. In the following sections, a new approach to coping with these problems is presented in detail.

Development of the electronic Library-Oriented learning environment

The electronic library-oriented learning environment, Library-Quest, has been developed. Figure 1 shows the structure of Library-Quest, which consists of five components: a Search Agent to derive relevant information from the electronic library which was designed by teachers, a Content Analyzer to recognize the derived information, a Content Reorganizer to reformat the information for show, a Searching Behaviors Recorder to record each students’ problem-solving portfolio, and a Searching Behaviors Analyzer to help the teachers analyze the students’ online behaviors based on their problem-solving portfolios.

To more effectively assist them in administering web-based problem-solving activities, the teachers can create learning activities, materials and student accounts in advance. According to the pre-defined user accounts, Library-Quest can provide different interfaces for students and teachers; hence, after the students log into Library-Quest, they will see a list of issues to be explored, which are pre-defined by the teachers. When the students choose an issue, a search interface for problem solving will be displayed.

As shown in the left snapshot of Figure 2, the student interface consists of four operation areas: The question and answer area is located on the left-hand side and can be hidden, the function-selecting area is located on the upper-right and provides several useful functions for problem-solving, such as simple search, advanced search, category
browsing, title browsing and author browse, the information-searching and result area is located on the lower-left of the window, and the content area is located on the lower-right for displaying the selected information, including text, images and video. An illustrative example of using the student interface is given in the right snapshot of Figure 2. After reading a question, the students can temporarily hide the “question and answer” area, such that they will have plenty of space to use the “category browsing” function to search for information and to browse the content that might be relevant to the question. The entire student portfolio, including the search functions that have been selected, the browsed content and the student behaviors, are recorded in the server.

Figure 1. Library-Quest system structure

Figure 2. Library-Quest student interface

Figure 3 shows the teacher interface for browsing the problem-solving portfolio of individual students. The problem-solving portfolio includes the answers to each question, the search functions that have been selected, the contents that have been browsed, and the browsing time for each content, etc. The “operation” column records the problem-solving behaviors of each student, including “submit answer,” “temporary answer,” “input keywords in simple search function,” “information selection in simple search function,” “browse content in simple search function,” “input keywords in advanced search function,” “information selection in advanced search function,” “browse content in advanced search function,” “browse content in category browsing function,” “browse content in title browsing function,” and “browse content in author browse function.” In the following, the search functions of Library-Quest are introduced in detail.
Operation:
13 = "submit answer", 14 = "temporary answer", 21 = "input keywords in simple search function", 22 = "information selection in simple search function", 23 = "browse content in simple search function", 31 = "input keywords in advanced search function", 32 = "information selection in advanced search function", 33 = "browse content in advanced search function", 44 = "browse content in category browse function", 52 = "browse content in title browse function", 63 = "browse content in author browse function".

**Figure 3.** Teacher interface for browsing the problem-solving portfolio of individual students

**Figure 4.** Example of using the “simple search” function to collect information for problem solving
The simple search function

Figure 4 shows the student interface for using the “simple search” function to collect information for problem solving. The student can enter keywords or a phrase to search for information in the selected field, browse the search results returned from the server which was created by the teachers, and then browse the content that might be relevant to the question.

The advanced search function

Figure 5 shows the student interface for using Boolean operators to gather information for problem solving. The student can input keywords or phrases to search for information in the selected fields with Boolean operators, browse the search results that are returned from the server which was created by the teachers, and then browse the content that might be relevant to the question.

Figure 5. Example of using the “advanced search” function to collect information for problem solving

Figure 6. Example of using the “category browsing” function to collect information for problem solving
The category browsing function

Figure 6 displays the student interface of using the “category browsing” function to obtain information for problem solving. The student can follow the steps as below, and then browse the content that might be relevant to the question.
Step 1: select a main category.
Step 2: select a secondary category based on the selected main category.
Step 3: select a title based on the selected secondary category and main category.

The title browsing function

Figure 7 illustrates the student interface for using the “title browsing” function to collect information for problem solving. The student can select a title, and then browse the content that might be relevant to the question.

![Figure 7. Example of using the “title browsing” function to collect information for problem solving](image1.png)

![Figure 8. Example of using the “author browse” function to collect information for problem solving](image2.png)
The author browse function

Figure 8 shows the student interface of using the “author browse” function to gather information for problem solving. The student can select an author, and then select a title based on the selected author to browse the content that might be relevant to the question.

Study 1: Teachers’ feedback of using Library-Quest

An experiment has been conducted to evaluate the “perceived ease of use,” “perceived usefulness” and “attitude toward using” of 103 elementary and high school teachers (the learning activity designers). The participants first experienced the learning activity development and analysis functions as well as the problem-solving interface of Library-Quest; next, they were arranged to use the problem-solving interface of Library-Quest to search for data from the electronic library to answer the questions concerning the ecological issues of the Chiku wetland in southern Taiwan. The Chiku wetland is the largest and the most intact lagoon in Taiwan. The main water source of the wetland is the Zengwun River which brings large varieties of biological, nutritive products, forming the excellent habitat. Many shorebirds, wildfowl and egrets gather on sandbars in the river, the most famous being the black-faced spoonbill. There are less than 2,000 black-faced spoonbills on the planet, of which 850 stay on the fish farm in the Chiku wetland each year from October to February. In this learning activity, the participants were asked to answer the following questions concerning the Chiku wetland:

(1) What are the representative birds in the Chiku ecological region in Taiwan? How are they distributed in this region?
(2) What are the migratory birds in Tainan which forage in the Chiku fish ponds? Does this area provide enough food for them?
(3) What are the representative plants in the Chiku wetlands? Do they have special features that are different from the plants in other areas?
(4) The government would like to urbanize the Chiku region. Do you agree with this? Why or why not?

After experiencing the use of the electronic library and the learning activity development procedure, the teachers were asked to complete a questionnaire that consists of three scales (six items for each scale), presented with strongly agree/disagree statements on a six-point Likert scale. Two experts in the field of Internet-based instruction had commented on the items of the questionnaire for face validity, and two elementary school teachers had been selected to clarify the wording of each item. A detailed description of the three scales is presented below.

(1) **Perceived usefulness scale**: assessing perceptions of the degree to which teachers expect that using Library-Quest will enhance students’ learning performance.
(2) **Attitude toward using scale**: measuring perceptions of the degree to which teachers will be willing to use it and recommend it to peers.
(3) **Perceived ease of use scale**: exploring perceptions of the degree to which teachers expect Library-Quest to be free of effort.

Teachers’ feedback via exploratory factor analysis

In accordance with the suggestions of Henson and Roberts (2006), Lee, Johanson, and Tsai (2008), and Worthington and Whittaker (2006), this study first examined the KMO measure of sampling adequacy index and Bartlett’s test of sphericity to ensure whether the samples are appropriate for exploratory factor analysis. The results indicated that the KMO measure of sampling adequacy index was 0.84, and Bartlett’s test of sphericity was significant ($\chi^2 (df = 78, n = 103) = 966.99, p < .0001$), showing that the samples are appropriate for this kind of analysis. Then, a principle components analysis with an oblique rotation was implemented on these items. According to the factors of the questionnaire seemed to be correlated, an oblique rotation was applied in this study. In addition, a combination of methods (e.g., conceptual clarity, eigenvalue > 1, and scree plots) were utilized to decide the number of the retained factors, suggesting that three factors should be retained. For the final version of the questionnaire, an item within a factor was retained only when its pattern coefficient (factor loading) was greater than 0.50 on the relevant factor and less than 0.50 on the non-relevant factor. Consequently, the initial 18 items were reduced to 13 items in the final version of the questionnaire (shown in Appendix A), and the total variance explained is 75.10%.
As shown in Table 1, the communalities \( h^2 \) of all items were at least 0.50. The retained three factors included Perceived usefulness (PU), Attitude toward using (A), and Perceived ease of use (EOU). The reliability (Cronbach’s alpha) for each factor is high (i.e., 0.93, 0.85 and 0.84, respectively; the overall alpha coefficient is 0.90), indicating that these factors had sufficient reliability for measuring teachers’ views toward Library-Quest.

<table>
<thead>
<tr>
<th>Table 1. Rotated factor pattern and structure matrices for the three factors ( n = 103 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Item</td>
</tr>
<tr>
<td>P S</td>
</tr>
<tr>
<td><strong>Factor 1: Perceived usefulness</strong></td>
</tr>
<tr>
<td>PU1</td>
</tr>
<tr>
<td>PU2</td>
</tr>
<tr>
<td>PU3</td>
</tr>
<tr>
<td>PU4</td>
</tr>
<tr>
<td>PU5</td>
</tr>
<tr>
<td><strong>Factor 2: Attitude toward using</strong></td>
</tr>
<tr>
<td>A1</td>
</tr>
<tr>
<td>A2</td>
</tr>
<tr>
<td>A3</td>
</tr>
<tr>
<td>A4</td>
</tr>
<tr>
<td><strong>Factor 3: Perceived ease of use</strong></td>
</tr>
<tr>
<td>EOU1</td>
</tr>
<tr>
<td>EOU2</td>
</tr>
<tr>
<td>EOU3</td>
</tr>
<tr>
<td>EOU4</td>
</tr>
</tbody>
</table>

*Note. P = Pattern coefficients; S = structure coefficients; \( h^2 \) = communalities of the measured variables.*

**Teachers’ ratings on the questionnaire**

Table 2 shows the teachers’ average ratings and standard deviations on the scales. The teachers gave the highest ratings on the “attitude toward using” scale, implying that an electronic library-oriented approach has potential to assist teachers in supporting web-based problem-solving activities; hence, the teachers are willing to keep using Library-Quest and recommend it to their peers. In addition, the teachers have positive perspectives of the electronic library-oriented approach and gave high ratings on all of the scales (above 4 on a 1-6 Likert scale), implying that an electronic library-oriented approach has high potential for supporting web-based problem-solving activities with proper user interface design and the provision of collocated functions. In sum, this study can conclude that the effectiveness of Library-Quest is accepted by most of the teachers.

<table>
<thead>
<tr>
<th>Table 2. Teachers’ ratings on the scales</th>
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</thead>
<tbody>
<tr>
<td>Scale</td>
</tr>
<tr>
<td>Perceived usefulness</td>
</tr>
<tr>
<td>Attitude toward using</td>
</tr>
<tr>
<td>Perceived ease of use</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 3. Gender comparisons of the teachers’ ratings of the scales</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scale</td>
</tr>
<tr>
<td>Perceived usefulness</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Attitude toward using</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Perceived ease of use</td>
</tr>
<tr>
<td></td>
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</tbody>
</table>

**p < 0.01**
Comparisons of usage feedback between male and female teachers

This study compared the responses of the male and female teachers, as shown in Table 3. The results revealed that there were no significant differences between the male and female teachers in terms of their beliefs of perceived usefulness and perceived ease of use; however, there were significant differences in the “attitude toward using” scale, with the male teachers having higher ratings on the scale than the female teachers. These results indicate that the male teachers expressed stronger willingness to keep using Library-Quest and to recommend it to their peers than did the female teachers.

The correlation among Internet usage experience, teaching experience and the questionnaire responses

As shown in Table 4, only one significant correlation is found among Internet usage experience, teaching experience and the questionnaire responses. That is, teachers’ age had a significantly positive relationship to the “attitude toward using” scale ($r = 0.22, p < 0.05$). This means that older teachers tended to have stronger willingness to keep using Library-Quest and recommend it to their peers. This finding is quite different from those of several previous studies that reported negative relationships between age and attitude toward using technologies (Lee & Tsai, 2010; Madden, Ford, Miller, & Levy, 2005; Martin, McCaughtry, & Kulina, 2008). In addition, most previous studies indicated that teaching experience was negatively related to attitude toward using technologies (Lee & Tsai, 2010; Yaghi, 2001); however, in this study, it was found that the experienced teachers had even more favorable attitudes than the inexperienced teachers in terms of using Library-Quest. Therefore, it is exciting to conclude that our approach has been readily accepted by those teachers, especially by those who are older and more experienced. Such a positive attitude expressed by senior and experienced teachers implies that our innovative approach has more potential than other information technologies to be widely accepted by teachers of different ages and backgrounds.

| Table 4. The correlation between teachers’ responses to the scales and their background |
|---------------------------------|-----------------|----------------|-----------------|----------------|
| Scale                           | Age             | Teaching experience | Web experience | Experience of Web-related pedagogical practice |
| Perceived usefulness            | 0.14            | 0.12              | -0.05          | 0.06           |
| Attitude toward using           | 0.22*           | 0.18              | 0.03           | 0.16           |
| Perceived ease of use           | 0.05            | 0.09              | 0.04           | 0.05           |

* $p < .05$

Study 2: The effects of Library-Quest on students’ learning performance

To investigate the effect of the proposed approach on students' learning performance, an experiment has been conducted on an elementary school natural science course. Moreover, the learning achievements and attitudes of the participants are measured to evaluate the effectiveness of the proposed approach.

Participants

The participants were two classes of grade six students from an elementary school in southern Taiwan. One class with 31 students (including 18 males and 12 females) was assigned to be the experimental group, and the other class with 31 students (including 20 males and 11 females) was the control group. Both groups of students were taught by the same teacher. The average of the students was 12. In other words, a quasi-experiment was undertaken for study 2.

Measuring tools and learning procedure

Before the learning activity, all of the students took a pre-test, which was developed by four experienced teachers for evaluating the students’ prior knowledge of natural science. The pre-test consisted of 17 yes-or-no questions, 19 multiple-choice questions and 3 fill-the-blank questions. The perfect score of the pre-test was 100.
During the learning activity, both groups of students were asked to answer the four questions concerning the Chiku wetland described before. The time of this learning activity was 50 minutes. The students in the experimental group employed the Library-Quest to search for data to answer the questions. On the other hand, the students in the control group were asked to answer the questions via the traditional technology-enhanced learning approach; that is, using common search engines to search for data from the web.

After the learning activity, all of the students took a post-test, which was developed by two experienced teachers for evaluating the students’ learning achievement during the learning activity. The post-test consisted of 5 yes-or-no questions, 5 multiple-choice questions, 2 check-all-that-apply questions and 2 question-and-answer items. The perfect score of the post-test was 30.

The students in both groups were also surveyed for their attitudes toward the science learning activity both before and after the treatment. The science learning attitude measure originated from the questionnaire developed by Hwang and Chang (2011). It consisted of 7 items with a six-point Likert rating scheme, where “6” represented “strongly agree” and “1” represented “strongly disagree.” The Cronbach's Alpha value of the science learning attitude measure was 0.94. For example, two of the questionnaire items were “It is worth learning the natural science course well” and “I will actively search for more information and learn about natural science.”

**Experimental results for study 2**

To evaluate the effectiveness of Library-Quest, ANCOVA is employed to analyze the post-test scores of the students by using the pre-test scores as the covariate to exclude the impact of the pre-test. The non-significant interaction of the independent variable and the covariate of the learning achievement test showed that $F = 1.92$ ($p > .05$), implying that the use of ANCOVA was appropriate.

Table 5 shows that the ANCOVA result, showing that the two groups had significantly different learning achievements with $F = 15.17$ ($p < .001$) after excluding the impact of the pre-test scores. The adjusted mean of the experimental group scored was 20.67, which was higher than that of the control group (i.e., 17.63), showing that the use of Library-Quest was helpful to the students in enhancing their learning achievement in this course.

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>Mean</th>
<th>S.D.</th>
<th>Adjusted Mean</th>
<th>Std. Error</th>
<th>$F$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Post-test (achievement)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Experimental group</td>
<td>31</td>
<td>20.58</td>
<td>3.95</td>
<td>20.67</td>
<td>.55</td>
<td>15.17***</td>
</tr>
<tr>
<td>Control group</td>
<td>31</td>
<td>17.71</td>
<td>2.31</td>
<td>17.63</td>
<td>.55</td>
<td></td>
</tr>
</tbody>
</table>

*** $p < .001$

This study further employed ANCOVA to analyze the learning attitude post-questionnaire scores of the students toward science by considering the learning attitude pre-questionnaire scores. The non-significant interaction of the independent variable and the covariate of the learning attitude scale showed that $F = 1.85$ ($p > .05$), implying that the use of ANCOVA was appropriate.

As shown in Table 6, the ANCOVA result was $F = 7.38$ ($p < .01$), showing that the learning attitudes of the two groups were significantly different after excluding the impact of the learning attitude pre-questionnaire scores. Moreover, the adjusted mean of the experimental group was 4.88, which was higher than that of the control group (i.e., 4.60), suggesting that Library-Quest approach was able to foster the learning attitude of students toward science.

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>Mean</th>
<th>S.D.</th>
<th>Adjusted Mean</th>
<th>Std. Error</th>
<th>$F$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Post-test (attitude)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Experimental group</td>
<td>31</td>
<td>4.96</td>
<td>0.54</td>
<td>4.88</td>
<td>.07</td>
<td>7.38**</td>
</tr>
<tr>
<td>Control group</td>
<td>31</td>
<td>4.53</td>
<td>0.86</td>
<td>4.60</td>
<td>.07</td>
<td></td>
</tr>
</tbody>
</table>

** $p < .01$
Conclusions

In the past decades, various powerful search engines have been developed that enable users to search for information from digital archives on the Internet. Such technologies for using and managing digital content have motivated educational applications on the Internet. Most current studies mainly focus on the issue of improving the efficiency of retrieving data from digital archives; nevertheless, one critical bottleneck of applying digital content to educational purposes is the lack of a way of assisting the teachers in conducting quality learning activities to guide the students to use digital content for problem-solving.

In this study, a web-based learning environment, Library-Quest, is proposed to cope with this problem. Library-Quest provides not only an electronic library-oriented learning environment for supporting web-based problem-solving activities, but also a mechanism for analyzing the problem-solving behaviors of the students. From the experimental results, it is found that Library-Quest is readily accepted by the teachers for developing and conducting web-based problem-solving activities. Moreover, there are several interesting findings that are quite different from those reported by previous studies (Lee & Tsai, 2010; Madden, Ford, Miller, & Levy, 2005; Martin, McCaughtry, & Kulinna, 2008). For example, the older teachers tended to be more willing to use Library-Quest, and the experienced teachers did not resist the use of Library-Quest as expected. This finding implies that developing extended learning facilities or functions is a good way to promote the application scope and utilization rate of electronic libraries. In addition, the positive attitude from older and experienced teachers toward the use of electronic libraries in learning is rarely seen in other technology-enhanced learning approaches, implying that electronic libraries have more potential to become a widely used learning tool than other information technologies.

Furthermore, from the experimental results of a natural science course, it was found that the use of Library-Quest not only improved the learning achievement of the students, but also improved their learning attitude toward science. Such findings conformed to what were reported by previous studies that students usually had difficulties in coping with problems in more open-ended environments (Brush & Saye, 2000). Research has concluded that higher degree of learner control may not necessarily facilitate learning, and sometimes it may impede learning (Lin & Hsieh, 2001). Good instructional designs should provide optimal learning control for students. The experimental results suggested that compared to common search engines for free navigation with full learner control, Library-Quest may offer optimal learner control for the students, thus enhancing learning achievements and attitudes.

From the findings of this study, it may be provided some insights for further research. However, this study was conducted using quantitative measures, which may not provide in-depth insights regarding students’ problem-solving abilities in an electronic library-based learning environment. Future studies are suggested to analyze students’ learning portfolios to find the problem-solving patterns of different learning-achievement students, which could provide important references to teachers for learning design. Moreover, the sample in this study only included elementary school students, and elementary and high school teachers. Future research should attempt to address this issue in other school levels (such as university) for receiving more feedback from both teachers and students.

Acknowledgements

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References


Boumarafi, B. (2010). Strategies for the delivery of e-information services to support the e-learning environment at the University of Sharjah. The Electronic Library, 28(2), 276-285.


Appendix A: The final version of questionnaire items

*Perceived usefulness (PU)*
  1. The use of Library-Quest is helpful to students for understanding the questions.
  2. The use of Library-Quest would enhance students’ ability to search for information when problem-solving.
  3. Library-Quest is helpful to the students in solving the questions.
  4. Library-Quest provides a good way of problem-solving.
  5. The use of Library-Quest makes students have more interest in the course.

*Attitude toward using (A)*
  1. I am willing to use other electronic libraries in the future.
  2. I have more willingness to use electronic libraries than before.
  3. I will actively look for information from electronic libraries.
  4. I hope I can participate in relevant activities like this one.

*Perceived ease of use (EOU)*
  1. It took only a short time to learn how to operate Library-Quest.
  2. The designs of Library-Quest’s interface fit users’ operating habits.
  3. The interface of Library-Quest is easy to operate.
  4. The search results which are displayed in Library-Quest are clear and easy to read.
Is Teacher Assessment Reliable or Valid for High School Students under a Web-based Portfolio Environment?

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*Corresponding author

ABSTRACT

This study explored the reliability and validity of teacher assessment under a Web-based portfolio assessment environment (or Web-based teacher portfolio assessment). Participants were 72 eleventh graders taking the “Computer Application” course. The students perform portfolio creation, inspection, self- and peer-assessment using the Web-based portfolio assessment system; meanwhile, the teachers used the assessment tool to review students’ portfolios and evaluate their learning performances. The results indicated that: 1) the Web-based portfolio teacher assessment achieved an acceptable level of reliability; 2) the Web-based portfolio teacher assessment, showing a strong level of inter-rater reliability and inner-rater reliability, can be regarded as a reliable assessment method; 3) the Web-based portfolio teacher assessment demonstrated an acceptable level of validity; 4) the portfolio scores were highly consistent with students’ end-of-course examination scores, implying that Web-based portfolio teacher assessment is a valid assessment method. Future studies are recommended to gain further insight into the self-built portfolios created by digital tools (e.g. PowerPoint, Word, or Frontpage software), for which effective rubrics and reliability or validity of the assessment may be also provided.

Keywords

Web portfolio, e-Portfolio, Portfolio assessment, Reliability, Validity

Introduction

Despite large time commitment required from both faculty and students, learning portfolios not only have positive influences on the quality as well as process of learning, but also offers a number of benefits not available as using conventional assessment approaches (Zalatan, 2001). Traditional paper-based portfolios are relatively ineffective in terms of inquiry, update, storage and management with particular difficulties in documenting various types of information, e.g. audio and video. Nevertheless, Chang and Tseng (2009a) stated this issue related to information storage can be settled by digital portfolios when technical support is available, such as floppy disk, hard disk, and CD-ROM. If not, Internet technologies may come into play. The Internet has markedly contributed portfolio assessment by establishing an excellent mechanism where learners are allowed to inspect and assess peers’ work online — this may not be possible for paper-based portfolio assessments.

Although learning portfolios have shifted from paper- to Web-based model, it is unfortunate that many Web-based portfolios, as an “assessment” tool, are not yet aligned with well-constructed scoring criteria. More than scoring standards, assessment rubrics play a facilitating role in students’ portfolio creation (Oskay, Schallies, & Morgil, 2008). According to Lynch and Purnawarman (2004), the digital portfolio assessments adopted by 35% American teacher preparation programs did not come along with scoring rubrics. Researchers including Johnason, Fisher, Willeke, and McDaniel II (2003) and Rogers (2003) claimed that presenting a concrete rubric in Web-based portfolio assessment is a crying need. It is desirable that rubrics are reasonably reliable and valid, since this is a key factor allowing effective evaluation and promising evidence. To date, portfolio rubrics are mainly concerned with conventional paper formats, while few are tailored to accommodate Web-based assessments. Although the rubrics of the two types of assessments may have something in common, there are some features that should be taken into account when assessing Web-based portfolios, such as multimedia design, information presentation and layout. In addition, current emphasis of assessment rubrics is placed on the descriptions of portfolio entries instead of students’ learning achievements (Bonita & Duquence, 1999; Danielson & Abrutyn, 1997; Johnason et al., 2003; Skawinski & Thibodeau, 2002). At this point, the fundamental purpose of an assessment — to measure learners’ achievements — cannot be served. Also, reliability or validity investigations so far have paid little attention to reliability and validity analysis of rubrics, largely focusing on the interpretations of assessment results. If a portfolio assessment is to be significant, rubrics that can accurately reflect learning achievements need to be developed, and the reliability as well
as validity should be investigated. Moreover, another question is being asked: do Web-based portfolios differ from those of paper versions in terms of rubrics, reliability and validity? Therefore, our research attempted to develop a meaningful rubric and to verify reliability and validity of the Web-based portfolio assessment.

In discussing reliability issues, Chang (2001) stated that rubrics are not easy to manipulate when utilizing portfolio assessment. Lu (2001) further pointed out there are several factors making the reliability dubious, including inconsistent scoring rubrics, ambiguous comments and limited capacity of student self- and peer-assessment. Yueh and Wang (2000) believed questionable reliability evidence is partly responsible for barriers to utilization of portfolio assessment. In validity research, Chang (2002) indicated that with little qualitative and quantitative research available, portfolio studies on reliability and validity primarily rely on the self-narratives from students and instructors to investigate teaching and learning effectiveness. As reviewing previous investigations of reliability and validity, Derham and Diperna (2007) stated that digital portfolios yet remain unexplored despite considerable amount of evidence available for paper-based formats. However, due to similar ways used to examine these two types of assessments, reliability and validity evidence based on paper assessments is still valuable to its counterpart (Brickley, Schewartz, & Hoi, 2000; Lenze, 2004). Furthermore, Lynchm and Purnavarman (2004) revealed a fact that only 2 out of 36 colleges and universities took advantage of rubrics to enhance the reliability and validity of digital portfolio assessment, while 25 of them did not. It is evident the establishment of rubrics will increase reliability and validity of digital portfolio assessment; however, the level it achieves and whether or not it is sufficient still remain unknown. It is a matter of great urgency developing assessment rubrics and verifying their reliability or validity.

This study involved teacher assessment, student self-assessment and peer-assessment. In order to explore a single dimension deeply, this study focused on the issues of teacher assessment. With above implications in mind, the purpose of this study was to investigate reliability and validity of teacher assessment under the web-based portfolio environment (or the Web-based teacher portfolio assessment) through a teaching experiment. Research questions are as follows:

1. Are the portfolio assessment results consistent among raters (teachers)?
2. Are the portfolio assessment results consistent within individual rater (teacher)?
3. Is each rubric aspect appropriate for examining learning achievements, i.e. are the portfolio scores consistent with the end-of-course examination scores?

Literature Reviews

Portfolio Assessment

In Alter and Spandle’s (1992) definition, a “learning portfolio” refers to an assessment tool purposefully collecting students’ work over a certain period of time, comprising evidence of self-reflection and students’ participation in selecting contents and constructing rubrics. In other words, a learning portfolio resembles a collection of individual pieces of work including reflection, selection of evidence, process of evaluation and artifact. Owing to technological advances, Web-based learning portfolios have been integrated into academic curricula in Europe and the USA as an authentic assessment and innovative teaching tool (Batson, 2002; Lorenzo & Ittelson, 2005; Singh & Ritzhaupt, 2006). Barker (2006) and e-Portfolio Consortium (2003) made comparable statements, asserting that Web-based learning portfolio functions as an online assessment approach for students, typically referred to Web-based Portfolio Assessment.

In assessing students’ learning performances, Rose-Hulman Institute of Technology developed and utilized RosE Portfolio System (REPS) (Burnett & Williams, 2009). Chang and Tseng (2009a) discovered that as using Web-based portfolio assessment, students’ overall performances are likely to be enhanced in term of goal setting, artifact, reflection, self- and peer-assessment, peer-interaction, data gathering and organization, continuous improvement and problem solving. Dennis, Hardy and White (2006) supported this statement by noting that the implementation of Web-based portfolio assessment not only enables students to display learning outcome, but also assists teachers in monitoring performances and giving feedback. C. Wang (2009) concluded the collaborative construction of digital portfolios plays a productive role in students’ learning process. In summary, the adoption of Web-based portfolio assessment is significantly beneficial to both teachers and students.
Rubrics of Portfolio Assessment

Wang, Peng and Lu (2006) used a portfolio assessment rubric to evaluate cross-cultural learning and students’ communication abilities. According to S. Wang (2009), digital portfolio assessment supposedly encompassed rubrics as well as feedback. Unfortunately, further discussions were not made in these previous studies. On the other hand, Skawinski and Thibodeau (2002) developed 3 types of rubrics — general, task-specific and comprehensive, each of which is further divided into 4 levels of performance. The General rubric addressed reflection and evidence of progress; Task-Specific delineated performance requirements for particular tasks; the Comprehensive rubric focused on overall quality of a portfolio. In the portfolio study of Johnason et al. (2003), rubrics are categorized into holistic and analytic. The Holistic is divided into four levels: proficient, developing, emerging, and not yet. In the Analytic rubric, there is a 5-point rating scale with descriptors at each extreme (Point 1 and 5) and the midpoint (Point 3) accompanying with a list of “look-fors”. This list contained observable behaviors and numerous examples of artifacts that equip instructors with a guide for rating and data collection. According to Johnason et al. (2003), this rubric was shown effective in raising inter-rater reliability.

An assessment rubric designed by University of Wisconsin-Stout (2010) was categorized into four aspects: technical, design, reflection and artifact. Another rubric comprising 7 aspects was also practiced at this university, including selection of artifacts, reflections, use of multimedia, layout and text elements, writing mechanics, annotations and creativity (Vandervelde, 2008). University of New England and ePortfolio Portal Team adopted a similar rubric dealing with selection of artifacts, reflections, use of multimedia, layout and text elements, writing mechanics, rationale or caption and ease of navigation (ePortfolio Portal, 2009; Rcampus, 2010). Warrant Community School utilized an assessment rubric created by Worcester (2000), including reflection, layout, folder structure, graphics, sounds, cooperation, presentation and mechanics. In Morris’s (2005) rubric, six aspects were incorporated, which were mechanics, graphics, use of tools, content relevancy, captions or reflections and structure; however, “artifact” was not integrated into this rubric. Moreover, the assessment rubric in Middlesex County College (2009) was characterized by 5 aspects: response of assignment, creative use of technology, attractiveness, reflection and grammar. In contrast, San Diego State University (2008) adopted a rubric quite different from the aforementioned. The rubric that contained 7 aspects entailed the following: personal profile/introduction page, standards matrix for artifact, artifacts and reflections, comprehensive reflection, usability, presentation and overall quality. Reflection, content and link and material were embodied in Microsoft Office’s rubric, while it was considered as over-simplified lacking the artifact aspect (Thompson, 2007).

The aforementioned assessment rubrics in nature tend to evaluate the quality of a portfolio rather than students’ overall learning performances (e.g. learning attitudes), lacking an aspect related to “goal setting.” Even so, several rubric aspects — artifacts, reflection and creation — were introduced into the assessment rubric at this study. Because artifacts and reflection were basically the key components in an e-portfolio and creation was an important activity for creating an e-portfolio. Some of Danielson and Abrutyn’s (1997) rubric aspects were also incorporated, e.g. goal setting, progress and accomplishment, and self-reflection. Based on the rubric from Ou (2002), we introduced another four aspects into our rubric which were achievement of a learning goal, collaboration with others, demonstration of personal characteristics, and capability of using resources. The degree of achievement of a learning goal was put in the aspect of “Learning Goal”; the degree to which a student shows personal characteristics and capability of using resources, in “Other”; the degree of collaboration with others, in “Attitude”. In summary, our rubric for portfolio assessment was classified into 6 aspects, Portfolio Creation, Learning Goal, Artifact, Reflection, Attitude and Other. Each aspect and their descriptors are suitable for a variety of academic disciplines; however, it is noted that the descriptors provided for the “Academic Subject Teaching Goals” in “Learning Goal” might vary from subject to subject.

Reliability and Validity of Portfolio Assessment

Reliability of Portfolio Assessment

To determine if portfolio assessment is reasonably reliable, Chang (2002) stated consistency of assessment results should be examined among different portfolios, raters, test time and situations because this is indeed what portfolio reliability involves. Internal reliability, or test-retest reliability, refers to the consistency within a rater in terms of the assessment results across the same item. External reliability refers to the consistency among multiple raters in terms
of the assessment results across the item. The research study conducted by Derham and Diperna (2007) as well as Gadbury-Amyot, Kim, Palm, Mills, Noble, and Overman (2003) was associated with external reliability. As a matter of fact, the RosE Portfolio System (REPS) adopted inter-rater reliability approach so that consistency across various raters can be ensured (Burnett & Williams, 2009). It is believed evaluators must discontinue an assessment once low levels of consistency across raters are detected.

The result of Gelinas’s study (1998) found that there was a high overall consistency between two portfolio raters. The study of Gadbury-Amyot et al. (2003) indicated that the correlation coefficients between two raters are statistically significant \( r = 0.28 \) and \( 0.6 \). The study of Rees and Sheard (2004) had similar results \( r = 0.36 \) and \( 0.69 \). Nevertheless, Yueh and Wang (2000) drew our attention to an issue: portfolio assessment, with particular focus on personalized learning, is often proved valid but not reliable. Yu (2003) stated that subjective judgment tends to affect assessment reliability. The study of Sulzen, Young and Hannifin (2008) claimed that increasing the number of raters was effective in reliability enhancement of portfolio assessment. Chang (2002) further pointed out there are several decisive factors making the sources of score variation diverse and complex — subjective scoring methods, insufficient number of portfolio entries, potential variety of portfolio contents, long duration of data collection, and so on. These may affect residual values that exist in traditional assessment reliability, resulting in lower level of the overall reliability.

There are a number of ways that can effectively improve the reliability of portfolio assessment. The role of well-defined scoring criteria is particularly critical in fostering the consistency among raters. Other factors will also lead to consistent results, such as appropriate portfolio rubrics, raters’ familiarity with rubrics, similar raters’ background and strict rater training. These factors should be taken into consideration before a portfolio assessment is ready to be conducted. Therefore, this study paid close attention and carefully dealt with the above factors during the experiments, aiming to reduce their negative effects.

Based on the literature reviews above, the hypotheses are as follows:

\[ H_1: \] The portfolio assessment results among teachers have statistically significantly correlation.

\[ H_2: \] The portfolio assessment results have statistically significant correlation within individual rater.

**Validity of Portfolio Assessment**

Russell and Butcher (1999) summarized a major challenge of portfolio assessment: portfolio data may not thoroughly reflect and document students’ learning processes and outcomes. That is to say, the validity of portfolio assessment may be an issue worth further exploration. When it comes to validity research, Chang (2002) indicated self-narratives from students and instructors are dominantly used to explore how portfolio assessment affects learning and teaching, resulting in the lack of systematic analysis and limited research evidence based on qualitative and quantitative methodologies. Chang (2002) further suggested the correlation between portfolio contents and assessment results can be improved via clear-cut learning objectives, which may be transferred to portfolio activities and entries. In addition, transferring learning objectives to scoring criteria is also useful to enhance the validity.

Sweat-Guy and Buzzetto-More (2007) explained that digital portfolio assessment conducted by multiple assessors has better opportunities to ensure validity. In other words, two or more assessors should be involved in the process of assessment. Yu (2003) asserted that validity research supported by external validity requires the existence of an exterior criterion object, e.g. the scores assigned by instructors. Gadbury-Amyot et al. (2003) investigated the correlation between portfolio scores and student achievement test scores by treating the latter one as an exterior criterion object. It is concluded that high correlation coincides with strong level of validity. Also, the concurrent-related validity was adopted by Derham and Diperna (2007) with the purpose of identifying how well a preservice teacher’s academic performances correlated with his/her digital portfolio assessment scores. The study of Gelinas (1998) found that there was a significant correlation between learners’ portfolio scores and their academic performance, implying the validity of portfolio assessment was adequate. A comparative analysis for reviewing several studies form Oskay, Schallies and Morgil (2008) claimed that portfolio assessment is not only valid but reliable. Sulzen, Young and Hannifin (2008), and Yueh and Wang (2000) also identified a sufficient validity for portfolio assessment. Given that the validity of teacher assessment was examined, this study instead took students’
end-of-course examination scores as exterior criterion; in the meantime, the correlation between teacher ratings and exam scores represents the validity of teacher ratings.

Based on the literature reviews above, the hypotheses are as follows:

H₃: The portfolio scores have statistically significant relation with the end-of-course examination scores.

**Method**

**Participants**

The participants were 79 eleventh-graders in the “Computer Application” course, among which the portfolios developed by 72 participants were completed and suitable for the statistical analysis. The participants, with basic computer skills including using the Internet, were taught 2 units of the computer course that addressed “Word Processing: Page Setup and File Edition.” The duration of the study was a 12-week period with 3 hours for each week. The participants performed portfolio creation, inspection and self- and peer-assessment via the Web-based portfolio assessment system developed for this study. The students didn’t have to create their portfolios by using presentation (e.g. Powerpoint) or Webpage (e.g. Frontpage) production software, rather by selecting the entries and filling out the forms in the Web-based portfolio assessment system to produce their e-portfolios. Teachers, on the other hand, employed this system in order to pace students’ learning progresses as well as to monitor their learning performances. The coursework of both units was digital-based that covered students’ operating skills and abilities to design. The students were allowed to electronically upload their work to the system, which was ideally compatible with the process of Web-based portfolio assessment.

**Procedure of Experiment**

The experiment included course unit 1 and course unit 2 with an artifact for each unit. Each course unit took 6 weeks. To elevate the reliability and validity, the experience of course unit 1 is particularly crucial for successful unit 2 in a way that increases grading skills and improves raters’ familiarity and shared perception of the assessment rubric. This study employed a full-blown and well-tested portfolio assessment activities designed by Chang and Tseng (2009a; 2009b), and the course activities are illustrated as below:

1) The teachers, i.e. 1 instructor and 3 online assistants, demonstrated system operation and offered guide for students by delineating the assessment rubrics, scoring methods and scoring criteria. The well-trained online assistants were the research members at this study who are fairly familiar with the assessment rubric and have a shared perception of the scoring standards.

2) Outside the classes, the students were involved in a number of course activities and online discussions. The activities for each course unit were: goal setting, reflection writing, artifact submission (including preliminary, revised, final versions of artifact), etc. The teachers viewed students’ learning processes through the assessment system. The end-of-course examination score was determined by the average of a student’s mid-term and final exam grades. The teacher, having over 10-year teaching experience, prepared the test forms for both exams.

3) Until each course unit ended, the teachers began to assess students’ portfolios; in the meantime, students performed self- and peer assessment. Prior to the evaluation, the 4 teachers had reached consensus based on assessment rubric and scoring criteria. The whole class was divided into 12 groups in which each group member anonymously assessed 6 portfolios from the other group. Thus, each teacher was responsible for 72 portfolios, while each student had to assess a total of 7 portfolios (1 personal and 6 peer portfolios).

In the section of “Portfolio Assessment”, teachers had access to a set of options by clicking on student names. These options were: Profile, Learning Goal, Reflection, Artifact, Other Entries, Scoring, Teacher Feedback, Peer Feedback, Participation Record, etc. By selecting “Scoring” option, teachers were allowed to report scores and write feedback (see Figure 1). Students’ portfolio contents and participation records could serve as a reference for teachers in their evaluation.
Development of Assessment Rubric

Our rubric was developed after reviewing the literature and discussing with the instructor in order to construct the face and content validity. The meetings with another three experts also helped to finalize the rubric and to establish expert validity. The rubric comprised 6 aspects with a total of 27 items, which were portfolio creation, learning goal, artifact, reflection, attitude and other entries (See Table 6 in Appendix). Scores were given ranging from 1 to 5, with a 0.5-increment in order to precisely distinguish the assessment results. In each rubric, various levels of performance were defined for precise scoring (see Figure 1).

In this study, we adopted a scoring method suggested by Reckase (2002), in which assessment results were converted to a hundred-mark system. To calculate a portfolio, original score was divided by the total score (160) with the quotient multiplying 100. Students’ portfolio results can be a reference for teachers in determining semester grades.

Item Analysis of Assessment Rubric

The assessment rubric was firstly measured using item analysis. The t-value between high-scoring (27%) and low-scoring groups (27%) for each rubric aspect achieved significance level, which implied each rubric aspect had good discrimination capability and should be reserved. The Pearson’s correlation between each rubric mean and overall mean was significant, showing that the consistency among rubric aspects was acceptably high and should be reserved.
Validity of Assessment Rubric

The Kaiser-Meyer-Olkin (KMO) values for each rubric aspect were greater than 0.5 (Table 1), implying that factor analysis could be applied. An approach of factor analysis—Principal Factor Analysis (PFA)—may be further used to construct validity. Considering that all factors (or aspects) had certain degree of correlation with one another, the oblique rotation approach was used conducting the PFA. The Chi-square approximate value of the Bartlett’s test reached significance level. This finding confirmed the existence of common factors between the rubric aspects, which showed the applicability of factor analysis. The results of factor analysis indicated factor loadings of one rubric in the Attitude aspect were lower than 0.3; the rubric was thus neglected. This was probably due to the reason that the attitude rubric asked about students’ opinions on the computer course, instead of on the portfolio assessment as other aspects did. However, the results of the second factor analysis revealed that all rubric aspects yielded factor loadings greater than 0.3. Therefore, all aspects were kept.

Five aspects with eigenvalues higher than 1 were refined. The overall explained variance was up to 90% (Table 1), indicating the overall scale had high validity. The explained variances of each aspect were greater than 60%; this suggested each aspect was valid and effective in investigating the quality of portfolio contents. Among all aspects, Attitude yielded the highest explained variance followed by Learning Goal, whereas Portfolio Creation held the lowest variance. This demonstrated that Attitude was most likely to examine the portfolio content quality, while Portfolio Creation was not.

![Table 1. Factor analysis of the assessment rubric](image)

<table>
<thead>
<tr>
<th>Aspect</th>
<th>KMO</th>
<th>Explained variance (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Portfolio Creation</td>
<td>0.61</td>
<td>61.50</td>
</tr>
<tr>
<td>Learning Goal</td>
<td>0.65</td>
<td>82.12</td>
</tr>
<tr>
<td>Artifact</td>
<td>0.83</td>
<td>72.82</td>
</tr>
<tr>
<td>Reflection</td>
<td>0.67</td>
<td>68.50</td>
</tr>
<tr>
<td>Attitude</td>
<td>0.66</td>
<td>83.26</td>
</tr>
<tr>
<td>Other</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Overall</td>
<td>0.86</td>
<td>90.81</td>
</tr>
</tbody>
</table>

Note: “Other” includes only one question, not applicable for factor analysis.

Reliability of Assessment Rubric

The rubric had high reliability with an overall Cronbach’s $\alpha$ greater than 0.7 (Table 2). All aspects were also higher than 0.7, revealing that the rubric had a high degree of internal consistency. The value for Artifact was the highest, while that of Reflection was the lowest.

![Table 2. Cronbach’s $\alpha$ value of the assessment rubric](image)

<table>
<thead>
<tr>
<th>Aspect</th>
<th>Cronbach’s $\alpha$ value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Portfolio Creation</td>
<td>0.71</td>
</tr>
<tr>
<td>Learning Goal</td>
<td>0.81</td>
</tr>
<tr>
<td>Artifact</td>
<td>0.85</td>
</tr>
<tr>
<td>Reflection</td>
<td>0.70</td>
</tr>
<tr>
<td>Attitude</td>
<td>0.81</td>
</tr>
<tr>
<td>Other</td>
<td>---</td>
</tr>
<tr>
<td>Overall</td>
<td>0.88</td>
</tr>
</tbody>
</table>

Results

Reliability of Portfolio Assessment

Research question 1: Are the portfolio assessment results consistent among distinct raters?
Table 3 summarized the Pearson’s correlation of 72 portfolio assessment results determined by 4 teachers (i.e. 1 instructor and 3 assistants). The results were highly correlated as well as significant. The hypothesis in the study was accepted. In other words, assessment results across 4 different teachers yielded a high degree of consistency. The greatest correlation coefficient appeared in the aspect of Portfolio Creation with the lowest in Reflection, indicating teachers were unlikely to reach consistency in the latter aspect. Although subjective judgment tends to affect assessment reliability (Yu, 2003), the findings in this study showed a strong correlation between evaluations based on 4 teachers. A comparable study result was elicited by Gelinias (1998), who found out there was a high overall consistency between portfolio raters. In the reliability research of Gadbury-Amyot et al. (2003), the correlation coefficients between 2 raters were measured ranging from 0.28 to 0.6; Rees and Sheard (2004) calculated the values between 0.36 and 0.69 — both study results were significant but lower than those of this study.

<table>
<thead>
<tr>
<th>Portfolio assessment</th>
<th>Correlation coefficient</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Portfolio Creation</td>
<td>1.00</td>
<td>0.000***</td>
</tr>
<tr>
<td>Learning Goal</td>
<td>0.98</td>
<td>0.001***</td>
</tr>
<tr>
<td>Artifact</td>
<td>0.84</td>
<td>0.019**</td>
</tr>
<tr>
<td>Reflection</td>
<td>0.75</td>
<td>0.034**</td>
</tr>
<tr>
<td>Attitude</td>
<td>0.94</td>
<td>0.006***</td>
</tr>
<tr>
<td>Other</td>
<td>0.93</td>
<td>0.000***</td>
</tr>
<tr>
<td>Overall</td>
<td>0.91</td>
<td>0.000***</td>
</tr>
</tbody>
</table>

**p<0.01, ***p<0.001

Research question 2: Are the portfolio assessment results consistent within individual rater?

The utilization of homogeneity coefficients is to investigate the consistency of an individual rater on different items, which was employed at this study in order to measure the consistency of a rater on distinct portfolios. The test for homogeneity evaluates the equality of several populations of a single categorical data by asking whether two or more populations are equal or homogeneous in some characteristics (Chiu, 2009). Therefore, the test of homogeneity of percentages was used to determine whether all the four raters (i.e. 1 instructor and 3 online assistants) demonstrated consistency in assessing different portfolio scores represented in the mode of percentage. The homogeneity analysis regarding the four raters is shown in Table 4. The homogeneity coefficients reached significance level, meaning each of the 4 teachers demonstrated consistency in terms of assessment results (i.e. inner-rater reliability). Likewise, the overall homogeneity coefficients were significant, implying the teachers were highly consistent in assessment results. The hypothesis in the study was accepted.

<table>
<thead>
<tr>
<th>Faculty</th>
<th>Individual coefficient</th>
<th>Individual Z-value</th>
<th>Overall coefficient</th>
<th>Overall Z-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Instructor</td>
<td>0.97</td>
<td>1.91**</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Assistant A</td>
<td>0.93</td>
<td>1.83**</td>
<td>0.95</td>
<td>1.87**</td>
</tr>
<tr>
<td>Assistant B</td>
<td>0.96</td>
<td>1.89**</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Assistant C</td>
<td>0.94</td>
<td>1.85**</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

** p <0.01

Validity of Portfolio Assessment

Research question 3: Is each rubric appropriate for examining learning achievements, or do portfolio scores match well with student achievement test scores?

The Table 5 showed the coefficients of Pearson’s correlation between portfolio scores and student achievement test scores. The result revealed that these two variables were not only correlated but also significant. The hypothesis in the study was accepted. This implied consistency indeed existed; thus, portfolio rubrics were appropriate for detecting students’ learning achievements. Gelinias (1998) made a statement in accordance with this finding: there is a positive correlation between learners’ portfolio scores and their academic performance. Besides, “Learning Goal”
and “Portfolio Creation” had higher possibility to reach consistency, for they were the two aspects with highest correlation coefficients.

| Table 5. Pearson’s correlation between portfolio scores and achievement test scores |
|---------------------------------|-----------------|-----------------|
| Aspect                          | Correlation coefficient | Significance |
| Portfolio Creation              | 0.78             | 0.000***        |
| Learning Goal                   | 0.79             | 0.000***        |
| Artifact                        | 0.67             | 0.000***        |
| Reflection                      | 0.63             | 0.000***        |
| Attitude                        | 0.59             | 0.000***        |
| Other                           | 0.57             | 0.000***        |
| Overall                         | 0.84             | 0.000***        |
| ***p<0.001                      |                  |                 |

**Discussion and Conclusion**

As far as reliability is concerned, there was a high consistency between various raters according to the quantitative analyses of Pearson’s correlation among 4 teachers (Table 3) and the homogeneity within an individual teacher (Table 4). Namely, the assessment was sufficiently reliable. When it comes to validity, students’ portfolio scores and achievement test scores were highly correlated and significant based on the Pearson’s correlation analysis (Table 5). This finding verified the existence of high consistency between the two variables; therefore, the portfolio assessment was appropriate for reflecting learning achievements. Taken together, Web-based portfolio assessment may be considered as reliable and valid. This conclusion coincides with the belief of other researchers.

Nevertheless, opposite results were discovered by Derham and Diperna (2007), who demonstrated contradictory findings in their reliability study of digital portfolios, in which correlation coefficients between 2 raters were weak and insignificant. They also figured out low and insignificant correlation coefficients in the validity research on digital portfolios. There are a number of factors that may be responsible for divergent research findings, including students’ backgrounds, sample sizes, the subject matter involved, digital portfolio environment, assessment rubrics, rating trainings, and scoring standards adopted. Oskay, Schallies and Morgil (2008), after reviewing relevant investigations, asserted that portfolio assessment is not only valid but reliable. Although disagreement can be found in past studies, most researchers treated portfolio assessment as a tool with reliability and validity. Even though low level of reliability was discovered, Sulzen, Young and Hannifin (2008) concluded increasing the number of raters was effective in reliability improvement. That is to say, it is not impossible having portfolio assessment reliable as well as valid.

All Cronbach’s α values of each rubric aspect exceeded 0.7; this signified portfolio rubrics had sufficient reliability. Among which, the highest value was measured in “Artifact” and the lowest in “Reflection”. In inter-rater reliability analysis, a high level of consistency appeared among 4 teachers in terms of assessment results. Likewise, in inner-rater reliability analysis, each rater was found highly consistent in scoring portfolios. Consequently, Web-based portfolio assessment may be a reliable approach that possesses both inter- and inner-rater reliability. In addition, many researchers indicated a number of factors that could ensure scoring reliability, including well-trained raters, concrete assessment rubrics, or raters’ common perception about scoring criteria (Derham & Diperna, 2007; Gadbury-Amyot, 2003; Oskay, Schallies & Morgil, 2008). Sulzen, Young, and Hannifin (2008) further pointed out that expanding the number of raters is also considered as instrumental in promoting reliability. This study attempted to provide assessors with opportunities for discussion and to help them become familiar with the rubric prior to the evaluation of portfolios. As a result, not only the inter-rater but also the inner-rater reliability was found to be significant. In response to reliability issues, we believe that raters are supposed to grade in an impartial way and have deep understandings and common perceptions about assessment rubrics. Among all aspects, the highest consistency level was discovered in “Portfolio Creation”. Conversely, “Reflection” held the lowest, meaning raters were unlikely to reach agreement in this aspect.

In factor analysis, the overall explained variances maintained high, which meant rubrics of Web-based portfolio assessment should be useful in measuring the quality of portfolios. Also, rubrics were capable of mirroring certain degree of learning achievements in light of the strong consistency observed between students’ portfolio scores and
achievement test scores. Given these findings, Web-based portfolio assessment and its rubrics had good level of validity. Chang (2002) noted assessors, during assessment process, must scrutinize various aspects of students’ learning. Therefore, it is concluded that assessment rubrics are preferably multifaceted and full-blown so that learning achievements can be faithfully evaluated.

Assessment rubrics in this study were framed under structured learning portfolios, in which learners created portfolios by filling out the identical form through the Web-based portfolio assessment system. Given that multiple rubrics may be needed to satisfy different types of portfolio, researchers should further construct compatible rubrics and have the reliability as well as validity examined, focusing on self-built digital portfolios via the use of PowerPoint, Word, or Frontpage software. The assessment rubric created at this study should be suitable for a wide range of academic disciplines due to its de-emphasis on the knowledge of subject matter content. It is worth noting that to allow efficient assessment, specific instructional objectives may be incorporated in the criterion related to teaching goals in the rubric of “Learning Goal” aspect. Quite different from their paper counterparts, our rubric, in Portfolio Creation, accentuates content richness by looking at the diversity of portfolio content formats (e.g. Word, PowerPoint, image, audio, etc.); self-reflections on peer feedback and peer performance are examined in Reflection; the aspect of Attitude specifically looks into online inspection and viewing, peer-assessment, feedback-giving, Web sources sharing, quality and quantity of online interaction, and so forth. For better statistical analysis results, we did not incorporate students’ achievement test scores in the assessment rubrics of this research. If achievement test scores are encompassed, portfolio scores can be regarded as learners’ overall academic scores. However, in analyzing the correlation between portfolio scores and achievement test scores, the latter variable must be removed in case double counting.

In the portfolio assessment study, the teacher and online assistants must spend enormous time grading student portfolios and double reviewing the graded portfolios based upon the assessment rubric. Consequently, they encountered the burdensome features of portfolio assessment and experiments. Moreover, we reported learning performances using the ABCD model (Audience, Behavior, Condition and Degree) in order to deal with the rubrics involving students’ cognition and skills. On the other hand, we attempted to provide examples to concretize students’ affective domain into observable events. By doing so, assessment validity was elevated to some extent, even though scoring-related controversies were not completely resolved. Perhaps, actual examples or concise descriptions should have been incorporated in the assessment rubrics. Oskay, Schallies and Morgil (2008) mentioned several principles that can be used to achieve high level of rater consistency. It is believed portfolios should be carefully introduced to students and should be of uniform content. In addition, portfolios should be scored by experienced and trained raters who use clear criteria, have a shared perception of the purpose of assessment and a deep understanding of expected student performance. The above principles, serving as a foundation of our study, are crucial in maximizing reliability and validity of portfolio assessment. Gadbury-Amoyot (2003) claimed that the reliability of portfolio assessment can be enhanced by concluded a larger sample. The smaller sample size used at this study might have negative influence on the analysis results. It is advisable that future studies may include a larger sample size, which tends to elicit promising reliability and validity.

References


<table>
<thead>
<tr>
<th>Aspect</th>
<th>Rubric</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Portfolio Creation</strong></td>
<td>1-1. Information completeness: To completely supply information required on the assessment system. 1-2. Content appropriateness: The content is directly related to the purpose of the portfolio. 1-3. Content richness: In addition to the requirements, extra information is provided to enhance the content of portfolio, e.g. achievement test results, classroom anecdotes or observation, course activity outcomes or link sharing. Note: To upload documents, various file formats are available such as audio, images, Word, PowerPoint, etc. 1-4. Organization and presentation: The layout is artful and clear and enhances the information presented.</td>
</tr>
<tr>
<td><strong>Learning Goal</strong></td>
<td>2-1. Personal goal setting: The student properly establishes pragmatic goals and anticipated results based on his/her ability, self-expectations, etc. 2-2. Teaching goals: The student achieves instructional goals related to the academic subject. For instance: In the “Computer Application” course, students are expected to acquire basic understandings about software operations and network construction and to realize the influence of technological advances on computer applications. Students also have to develop positive attitudes in using computers and recognize the value of peer collaboration. 2-3. Progress and accomplishments: The student shows progress and improvement in learning attitudes and academic performance. 2-4. Goal attainment: The degree to which learning goals are achieved.</td>
</tr>
<tr>
<td><strong>Artifact</strong></td>
<td>3-1. Correctness: The correctness of the student’s artifacts. 3-2. Appropriateness: The appropriateness of the student’s artifacts. 3-3. Richness and completeness: The richness and completeness of the student’s artifacts. 3-4. Difficulty level: The difficulty level of the student’s artifacts. 3-5. Creativity and originality: The creativity and originality of the student’s artifacts. 3-6. Comprehension of course content: The student’s comprehension of the course content. 3-7. Process of artifact production: The evidence that demonstrates the process of artifact development is included (e.g. draft, original and revised versions of work).</td>
</tr>
<tr>
<td><strong>Reflection</strong></td>
<td>4-1. Reflection on learning goals: The student’s reflections related to learning goals. 4-2. Reflection on artifacts: The student describes the process and outcomes of artifact development. 4-3. Reflection on learning achievements: The reflections illustrate the student’s learning achievements, weaknesses and progress. 4-4. Reflection on attitudes: The reflections show the student’s learning attitudes and growth.</td>
</tr>
</tbody>
</table>
4-5. Reflection on peer performance:
The student sets suitable self-expectations after reviewing the content of peer portfolios.
Note: Peer observation and mutual assessment are available on the Web-based portfolio assessment system.

4-6. Reflection on feedback:
The reflections on teacher and peer feedback are accompanied by explanations or follow-up modifications.
Note: Peer observation and mutual assessment are available on the Web-based portfolio assessment system.

<table>
<thead>
<tr>
<th>Attitude</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>5-1</td>
<td>Online inspection and viewing, peer-assessment, feedback giving:</td>
</tr>
<tr>
<td></td>
<td>The student makes appropriate comments and feedback according to the content of peer portfolios.</td>
</tr>
<tr>
<td></td>
<td>Note: Peer observation and mutual assessment are available on the Web-based portfolio assessment system.</td>
</tr>
<tr>
<td>5-2</td>
<td>Resource sharing:</td>
</tr>
<tr>
<td></td>
<td>Relevant resources are offered via the assessment system.</td>
</tr>
<tr>
<td>5-3</td>
<td>Online forum, knowledge sharing, idea exchange, Q&amp;A:</td>
</tr>
<tr>
<td></td>
<td>To practice online discussion, knowledge sharing, idea exchange and problem solving via the assessment system.</td>
</tr>
<tr>
<td></td>
<td>For example: The student actively participates in discussion forum and Q&amp;A, offers peer assistance or encouragement and looks for solutions to problems.</td>
</tr>
<tr>
<td>5-4</td>
<td>Quantity of online interaction:</td>
</tr>
<tr>
<td></td>
<td>Students are scored based on online activity records involving the amount and duration of portfolio reviews, length and numbers of posts, etc. Comparable points are given according the ranking.</td>
</tr>
<tr>
<td>5-5</td>
<td>Quality of online interaction:</td>
</tr>
<tr>
<td></td>
<td>Peer feedback or critiques are written properly and promote constructive interaction.</td>
</tr>
<tr>
<td></td>
<td>For example: The student shows positive peer interaction by making unbiased and reasonable comments.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Other</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>6-1</td>
<td>Supporting examples or evidence:</td>
</tr>
<tr>
<td></td>
<td>Additional evidence is given to demonstrate the student’s learning process or academic growth.</td>
</tr>
</tbody>
</table>

Note: 1. In each rubric, various levels of performance were defined for precise scoring.
2. Students’ achievement test scores were not incorporated in this rubric.
E-learning Systems Support of Collaborative Agreements: A Theoretical Model

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ABSTRACT
This paper introduces a theoretical model for developing integrated degree programmes through e-learning systems as stipulated by a collaboration agreement signed by two universities. We have analysed several collaboration agreements between universities at the national, European, and transatlantic level as well as various e-learning frameworks. A conceptual model, a business model, and the architecture design are presented as part of the theoretical model. The paper presents a way of implementing e-learning systems as a tool to support inter-institutional degree collaborations, from the signing of the collaborative agreement to the implementation of the necessary services. In order to show how the theory can be tested one sample scenario is presented.

Keywords
Collaboration agreements, Distributed learning environments, E-learning, Joint degrees, Globalization

Introduction
The development of joint degrees is an important mechanism for strengthening academic research collaborations and diversifying knowledge. There is currently a wide range of joint and double degrees on offer. Both of these degrees are offered through the collaboration between at least two universities. The development of joint degrees requires joint curriculum development and very close cooperation between the partner institutions because the associated administrative and academic processes are managed jointly.

Joint degrees are becoming increasingly implemented in universities around the world. The number of joint degree programmes has grown dramatically in recent years. In Europe, both the Bologna process and the Erasmus programme have encouraged global recognition of joint and double degrees.

Collaboration and internationalization are important strategies for gaining access to the global market. The current global economic crisis is having a marked impact on certain internationalisation activities (Egron-Polak & Hudson, 2010) as a result of the extra financial cost to students for mobility. E-learning can help to reduce these expenses, enhance the diversity of programmes, and extend into new markets.

Technology and communication infrastructure provide better opportunities to deliver online courses and thus support e-learning. According to Euler, Seufert, and Moser (2008), e-learning is a tool that facilitates the servicing of a new market; it offers the potential to enhance the programme profile of a given university to include other services, as well as being used for the enhancement of university teaching and the implementation of internationalisation in education. The European commission has integrated various educational and training initiatives under the Lifelong Learning Programme of 2007–2013. There are several ways of promoting the use of e-learning as a collaborative tool.

Service-oriented approaches in e-learning systems are gaining popularity with the increasing adoption of web services and the lower integration costs coupled with the flexibility and simplification of the configuration. Below are some examples of service-oriented approaches. A web service architecture for e-learning is presented to solve the problem of interoperability between different learning systems (Qiu & Jooloor, 2006). Fang and Chien (2009) highlighted the need to integrate SOAs to enhance the interoperability, flexibility, and reusability of e-learning content in a collaborative environment. Cheng, Huang, and Nong (2008) proposed a methodological framework for the development of e-learning systems based on an SOA and a Model Driven Architecture (MDA). These proposals are interesting; however, none of them involves the management of e-learning architectures based on collaboration agreements.

Our motivation is to present the usefulness of e-learning as a tool to support the development of joint degrees based on collaboration agreements. A new domain of e-learning system is presented. This approach should help...
universities participate in new markets and create strategic alliances. Moreover, it should allow students to benefit from global curricula and learning environments by providing students with the opportunity to develop language skills as well as other abilities needed to work and participate in multicultural environments. It is important that the participating universities ensure the quality of the joint degrees they offer. This implies that they have a qualified staff as well as first-rate academic programmes, learning facilities, and student support.

**Literature review**

**Joint degrees**

Joint degrees are academic programmes implemented by two education institutions on the basis of written agreements. Joint degrees are seen as a principal instrument for developing the European Higher Education Area (EHEA) and for improving the competitiveness of European higher education around the world (Knight, 2008).

A survey report, “Joint and Double Degree Programs in the Transatlantic Context” (Kuder & Obst, 2009), found that double degrees appear to be much more common than joint degrees, and a large majority of both US and EU institutions plan to develop more joint and double degrees in the future. The major findings of this report are summarised in Table 1.

<table>
<thead>
<tr>
<th>Institutions</th>
<th>United States</th>
<th>Europe</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Top 5 partner countries</strong></td>
<td>Germany, China, France, Mexico, and South Korea/Spain</td>
<td>United States, France, Spain, Germany, and the UK</td>
</tr>
<tr>
<td><strong>Desired partners for future joint degrees</strong></td>
<td>China, India, Germany, and France</td>
<td>United States, China, Germany, Canada, and the UK</td>
</tr>
<tr>
<td><strong>Educational level</strong></td>
<td>More likely at undergraduate level</td>
<td>More likely at graduate level</td>
</tr>
<tr>
<td><strong>The most popular academic disciplines</strong></td>
<td>Business and Management Engineering</td>
<td>Business and Management Engineering</td>
</tr>
<tr>
<td><strong>Probability of students participation</strong></td>
<td>Less likely</td>
<td>More likely</td>
</tr>
<tr>
<td><strong>Cover cost with students feeds</strong></td>
<td>More likely (institutions tend to draw more funding from university budgets and external sources.)</td>
<td>Less likely</td>
</tr>
<tr>
<td><strong>Language of instruction</strong></td>
<td>English</td>
<td>English and home language</td>
</tr>
<tr>
<td><strong>Most important challenges</strong></td>
<td>Adequate funding and sustainability Institutional support and recruiting students</td>
<td>Adequate funding and sustainability Difficulties in designing the curriculum and agreeing on credit transfer recognition</td>
</tr>
<tr>
<td><strong>The key motivations</strong></td>
<td>The internationalisation of the campus and raising international visibility and prestige of the institution</td>
<td>The internationalisation of the campus and raising international visibility and prestige of the institution</td>
</tr>
<tr>
<td><strong>Selection process</strong></td>
<td>Student selection is done by each institution separately but based on shared criteria.</td>
<td>Student selection is done by each institution separately but based on shared criteria.</td>
</tr>
</tbody>
</table>

According to the 2005 IAU global survey on the internationalization of higher education (Knight, 2005), the implementation of institutional agreements and networks together with the development of joint and double degrees are the 1st and 10th priorities, respectively, of the 17 internationalisation policies. The initial results of the 3rd IAU Global Survey (Egron-Polak & Hudson, 2010) ranked the development of joint or double degrees as the fifth institutional priority in internationalisation of higher education.

Joint degrees are being developed worldwide. A few examples of funding programmes available to promote integrated degrees include the European Union-United States Atlantis programme (http://www2.ed.gov/programs/fipsec), the Erasmus Mundus programme, the Singapore-MIT Alliance
(http://web.mit.edu/sma/), and the Worldwide Universities Network (http://www.wun.ac.uk). Table 2 lists examples of joint degrees at the bachelors, Masters, and PhD levels.

<table>
<thead>
<tr>
<th>Joint Degree</th>
<th>University</th>
</tr>
</thead>
<tbody>
<tr>
<td>Master's in Public Administration</td>
<td>University of Alaska Southeast (USA) and Yukon College (Canada)</td>
</tr>
<tr>
<td>Master’s in International Studies</td>
<td>Johns Hopkins University (USA) and Nanjing University (China)</td>
</tr>
<tr>
<td>Master's in Business Administration (MBA)</td>
<td>New York University (USA), London School of Economics (UK), HEC Paris (France), and National University of Singapore (Singapore)</td>
</tr>
<tr>
<td>European MBA</td>
<td>Deusto University (Spain), AUDENCIA-Nantes Ecole de Management (France), and Bradford University (UK).</td>
</tr>
<tr>
<td>PhD in Medicine</td>
<td>Makerere University (Uganda) and Karolinska Institutet (Sweden)</td>
</tr>
<tr>
<td>Master’s in History of South-Eastern Europe</td>
<td>Babeș-Bolyai University of Cluj-Napoca (Romania), University of Graz (Austria), and University of Ljubljana (Slovenia)</td>
</tr>
<tr>
<td>Bachelor of Engineering</td>
<td>Universidad del Norte (Colombia) and University of South Florida (USA)</td>
</tr>
<tr>
<td>European Master’s Program in Computational Logic</td>
<td>Universidad Politécnica de Madrid (Spain), Dresden University of Technology (Germany), Free University of Bozen-Bolzano (Italy), Vienna University of Technology (Austria), and New University of Lisbon (Portugal)</td>
</tr>
</tbody>
</table>

Eckel (2003) identified and described one trend emerging from globalisation; namely, American colleges and universities are leveraging their curricula internationally through joint ventures with other universities or with other partners such as corporations, non-profits, and non-governmental organisations, which result in new academic programmes that each partner alone could not offer.

Collaboration agreements

In this context, contracts or collaboration agreements formalise an agreement between universities working toward a common objective, which is the development of a joint degree. A collaboration agreement states the rights and obligations of the parties involved as well as the control policies that are applicable under it.

Figure 1. Categories of collaboration agreement issues

To identify the variables, rules, components, and roles that should be taken into account in our approach, we have analysed several collaboration agreements between universities at the national, European, and transatlantic levels such as:

- Dual Degree Master Program in Computer Science between KAIST Department of Computer Science (Korea) and Technische University at Berlin (Germany).
- Joint degree programme agreement at the School of Nursing and the Divinity School of Yale University (USA).
• Agreement on a joint diploma/degree program between Alpen-Adria Universität Klagenfurt (Austria) and Poznan University of Technology (Poland).
• Joint degree programme agreement between Sheridan College (Canada) and York University (Canada)
• Model general of collaboration agreement between Universidad Politécnica de Madrid (Spain) and academic partner
• Collaboration agreement between National University of Singapore (Singapore) and University of Melbourne (Australia)
• Some key terms of the collaboration agreements in UK are presented in the report publish by Eversheds (2009).

In accordance with this analysis, the collaboration agreement can be divided into six categories: academic, administrative, context, security, financial, and legal (Figure 1). Some issues that belong in the first four categories can be managed through e-learning systems.

Table 3 summarises the general issues stipulated in a collaboration agreement regarding joint degrees. The issues that can be managed and implemented through the e-learning systems are italicized in Table 3. The rest of the issues require manual process and they are independent of any technical implementation.

<table>
<thead>
<tr>
<th>Collaboration agreement issues</th>
<th>Academic</th>
<th>Administrative</th>
<th>Context</th>
<th>Security</th>
<th>Financial</th>
<th>Legal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Joint curriculum</td>
<td>Enrolment rules</td>
<td>Academic calendars</td>
<td>Access control and security policies</td>
<td>Programme fees</td>
<td>Legal recognition</td>
<td></td>
</tr>
<tr>
<td>Admission requirements</td>
<td>Duration and conditions of the agreement</td>
<td>Language of instruction</td>
<td>Data protection</td>
<td>Financial aid</td>
<td>Legal status</td>
<td></td>
</tr>
<tr>
<td>Assessment</td>
<td>Credit transfer recognition</td>
<td>Credit format</td>
<td></td>
<td>Money exchange rate</td>
<td>Intellectual property</td>
<td></td>
</tr>
<tr>
<td>Quality assurance</td>
<td>Recruitment strategies</td>
<td>Programme dissemination</td>
<td></td>
<td>Sustainability</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Administrative, teaching, and technical staff</td>
<td>Awarding of degrees</td>
<td></td>
<td>Marketing</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Distribution of incomes between partners</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

E-learning frameworks

In the same way that we examined collaboration agreements, we analysed several e-learning frameworks to identify the main components that an e-learning system should include to facilitate the development of integrated study programmes. The e-learning frameworks identify and specify the main components and services that may be implemented by an e-learning system. Table 4 presents an overview of the main layers specified by the most common e-learning frameworks based on services-oriented approach such as: ELF, IMS Abstract Framework, and OKI.

<table>
<thead>
<tr>
<th>Frameworks</th>
<th>Layers</th>
</tr>
</thead>
<tbody>
<tr>
<td>ELF</td>
<td>User Agents Learning Application services</td>
</tr>
<tr>
<td></td>
<td>Common Services</td>
</tr>
<tr>
<td>IMS Abstract Framework</td>
<td>Application</td>
</tr>
<tr>
<td></td>
<td>Application services</td>
</tr>
<tr>
<td></td>
<td>Common Services</td>
</tr>
<tr>
<td></td>
<td>Infrastructure</td>
</tr>
<tr>
<td>OKI</td>
<td>Educational Applications Educational Services</td>
</tr>
<tr>
<td></td>
<td>Common Services</td>
</tr>
<tr>
<td></td>
<td>Infrastructure</td>
</tr>
</tbody>
</table>
In 2004, the JISC released an initial technical framework to support e-learning that consisted of a set of services. This e-learning framework was expanded to include international partners as well as other domains such as resource management, research, and academic administration. This new approach is referred to as the e-framework which is an initiative to promote the use of a service-oriented approach in the analysis and design of software for use in education and research (Nicholls, 2009).

As regards e-learning systems, we have selected some criteria oriented to services which can be of interest when implementing a service-oriented architecture (Table 5).

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Moodle</th>
<th>dotLRN</th>
<th>Blackboard</th>
<th>Sakai</th>
</tr>
</thead>
<tbody>
<tr>
<td>Development Language</td>
<td>Php</td>
<td>Tcl</td>
<td>Java</td>
<td>Java</td>
</tr>
<tr>
<td>Web services protocols</td>
<td>AMF, REST, SOAP, XML-RPC</td>
<td>REST, XML-RPC, SOAP</td>
<td>SOAP</td>
<td>SOAP, REST</td>
</tr>
<tr>
<td>Web services Development</td>
<td>Modules based on php</td>
<td>Web Framework based on OpenACS, TWIST (Tcl web Service Toolkit)</td>
<td>Blackboard Building blocks or JWS (Java web Service).</td>
<td>JWS implemented in Apache Axis</td>
</tr>
<tr>
<td>License</td>
<td>Open source</td>
<td>Open source</td>
<td>Commercial</td>
<td>Open source</td>
</tr>
<tr>
<td>Authentication</td>
<td>CAS, External DB, First class, LDAP, IMAP, NNTP, Moodle network, PAM, POP3, RADIUS, Shibboleth, web services</td>
<td>LDAP, PAM, RADIUS, web services</td>
<td>CAS, LDAP, Kerberos, RDBMS, ActiveDirectory, Shibboleth, web server delegation</td>
<td>CAS, LDAP, Shibboleth, Kerberos, web services</td>
</tr>
<tr>
<td>Syndication feeds</td>
<td>RSS, ATOM</td>
<td>RSS, ATOM</td>
<td>RSS, ATOM</td>
<td>RSS, ATOM</td>
</tr>
</tbody>
</table>

### Theoretical model

#### Conceptual model

To evaluate whether an e-learning system can be used as a means to develop joint degrees, we first defined the conceptual model. Based on different case studies (Dougherty & Su, 2009; Banks, 2006), we identified the main phases that are carried out during the specification and development of a joint degree. Figure 2 illustrates the main phases ranging from the recognition of the benefits of integrated programmes to the examination of the degrees.

The first four phases are related to the specification of objectives, resources, and terms of the agreement. The following four phases, which are related to the development of the programme, can be automated and implemented through e-learning systems.

Figure 3 presents the conceptual model according to which universities can participate in the creation of new academic degrees using their e-learning systems. Partner universities should establish collaboration agreements to develop a joint degree. First, they need to work on the terms of agreement and find solutions to every difference of opinions for the success of the integrated degree programme. Once the partners have identified, defined, and negotiated all of the terms, the signing of the collaboration agreement will be the culmination of the specification process. If the agreement is signed, the next step will be to translate it into a technical language to manage the e-learning systems in accordance with the terms specified.
Students enrolled in a joint degree can access it through any participating e-learning system. Universities must ensure both the access to their e-learning system and the availability of all services and content needed to complete the joint degree. The main obstacles, benefits, and challenges to overcome in the context of e-learning systems and joint degrees have been identified (Aguirre, Quemada, & Salvachúa, 2010).

In relation to the collaborative agreements issues identified in the previous section, the implementation of the conceptual model means that many of these issues can be considered as limitations because they can block the process. These key issues are presented in the next section.
Key issues and limitations

Taking into consideration the issues stipulated in a collaboration agreement (Table 3), we have analyzed which of them can be managed through e-learning systems and which can be considered as limitations.

Academic level

Joint degrees are based on a curriculum developed jointly by the participating partners. The specification of the curricula will determine the courses that each partner will have to offer and support in their e-learning systems. Each partner must ensure both the access to their e-learning system and the availability of all courses and functionalities needed to develop the joint degree. Both the admission criteria for entering the programme and the assessment methods have to be jointly specified by both participating institutions.

The globalisation of higher education generates a number of crucial challenges, which require the intervention of an international regulatory framework for quality assurance and accreditation. The joint degree consortium should ensure that participating institutions are officially accredited in their home country. Likewise, their programmes should be accredited by a national accreditation agency. Some agencies for quality assurance include the National Agency for Quality Assessment and Accreditation of Spain (http://www.aneca.es/), the European Association for Quality Assurance in Higher Education (http://www.enqa.eu/), and the Qualifications and Curriculum Development Agency in United Kingdom (http://www.qcda.gov.uk/default.aspx).

A major limitation in this context is the different teaching styles that each partner can follow. Banks (2006) presented a case of study on the experience of developing intercultural collaboration in a UK-Chinese context. The UK’s theoretical approach to e-learning follows a social-constructivist view of learning whereas the Chinese approach to e-learning has been influenced by instructional system design (problem-based learning). Academic staff in some countries must learn to work as part of pedagogical teams, which represents a challenge to those cultures where teachers are individually responsible for what they teach without any coordination required at the programme level. The high average age of the teaching staff can also be an obstacle to adopting the new methods and ideas (Sursock & Smith, 2010).

Administrative level

The administrative support in the development of an integrated programme through e-learning systems plays a crucial role. From our point of view, e-learning systems could offer support to the following issues: user registration, generation of administrative reports, and the control of service availability according to the duration of the agreement.

Manual process is required to define the enrolment rules, credit transfer recognition, programme dissemination activities (e.g., brochures, home page), recruitment strategies, generation of academic certificates, staffing, and awarding of degrees.

Context level

At this level we have grouped the issues that we identified as more dependent on the scope (national or international) in which a joint degree is developed.

Academic calendars can differ from country to country. When the time difference is large, the scheduling of courses and virtual meetings are a challenge. Lack of harmonization of academic calendars is a limitation although the e-learning systems can help to manage it. The management of different credit formats and its allocation has to be specified. A table of equivalence of the different types of credit must be specified. This table can be managed in e-learning systems. Along with the latest Trends report (Sursock & Smith, 2010) most of the institutions in Europe have reported the use of ECTS for credit accumulation, and only England, Wales and Northern Ireland and Lithuania are using a different credit transfer system.
Institutional resistance to change is an important limitation at a context level. Therefore, academic institutions have to promote international cooperation and intercultural experience through bilateral contacts, consortia, and treaties. Consortia serve as platform for bilateral agreements between their members.

Additional difficulties are associated with language and cultural barriers. Students with different cultural backgrounds may understand the same e-learning website in different ways (Mushtaha & De Troyer, 2007). Cultural aspects and website design have an intrinsic relationship. Navigation, page orientation, menus, language, colors, information organization, and images have been identified as elements with distinctive cultural attributes (Callahan, 2005). Edmundson (2007) designed the Cultural Adaptation Process (CAP) model as a guide for evaluating existing e-learning courses and for matching them to the cultural profiles of targeted learners. Internationalization and localization is being implemented in e-learning systems to adapt different languages, regional, and culture differences.

English is dominant as the foreign language of most interest to students. According to the OECD report (2010), an increasing number of institutions in non-English-speaking countries are offering courses in English to overcome their linguistic disadvantage in terms of attracting foreign students. In the development of a join degree between the University of Kansas (KU) and the Korean University of Technology and Education (KUT), KU students have found that even though KUT courses are taught in English, the question/answer sessions may be in Korean, thus leaving the non-Korean speaking student without valuable information (Dougherty & Su, 2009). Therefore the choice of a common language is important for the success of this scenario.

At the political level, initiatives for promoting regional integration in higher education are being carried out, for instance, the Bologna Process in Europe is an attempt to create the EHEA, the Association of Arab Universities (AARU) enhances cooperation between members of the association, the Association of African Universities (AAU) proposes the creation of the “African Higher Education Area” (AHEA) and the UNESCO International Institute for Higher Education in Latin America and the Caribbean (IESALC) is in Latin America.

Security level
Since the scenario of joint degrees involves the exchange of personal data and students between partner universities, the data protection must be clearly defined. Copyright management may require a shared consensus of all the members of consortium.

E-learning systems must provide a secure access control and a reliable security policy management. In order to avoid sharing personal data it is safer for each member of a joint degree to carry out the registration process in each e-learning system of the participating partners. A reliable system of backup must be available.

Financial level
The economic crisis is having a marked impact on the internationalization process as a result of the extra financial cost to students for mobility. E-learning can help to reduce these expenses, enhance the diversity of programmes and extend into new markets. The tuition fees should be charged by each institution. The numbers of student admitted by each university have to be specified. A business model for this scenario is presented below.

Legal level
One of the main difficulties of developing joint degrees is related to legal recognition of the degrees. A joint degree should be recognized outside of the consortium and in a wider international context. In some countries, universities are not allowed to award a degree unless the students spend their last academic year at this university. A joint degree should be recognized outside of the consortium and in a wider international context. Non-recognition and limitations on the numbers of courses or credits taken at a partner university raise additional barriers (Knight, 2009). Double degrees can be an alternative solution in those countries where legal restrictions prevent the recognition of a joint degree.
Although the ministers of Education in some countries are promoting the creation of joint degrees, there is no change of legislation leading their recognition. Only a few countries allow a domestic university legally to confer a joint qualification in partnership with a foreign institution (Knight, 2009).

Nowadays, there are consortia promoting regional cooperation and facilitating the mutual recognition of study achievements. A consortium like the European Confederation of Upper Rhine Universities (EUCOR) aims to promote cooperation in education and research among some universities in Germany, France, and Switzerland.

An interesting legal guide for the UK universities on collaboration with overseas partnerships has been published by Eversheds (2009). This guide includes higher education jurisdiction of some partnerships such as Australia, China, Hong Kong, India, Malaysia, UAE, Qatar, and USA.

**Technical level**

Heterogeneity of e-learning systems is a limitation in the development of integrated study programs. The implementation of a common services layer is the proposed solution for this scenario. The use of standards has to be promoted in order to facilitate the interoperability of learning objects.

The use of a notification system for e-learning will allow all members to deliver and receive messages. The adaptation of an effective evaluation system is important to obtain feedback on performance, usability from their students, teaching staff, administrative (all roles) that can be used for future improvements.

Speed, stability, and security in telecommunications infrastructure have an enormous impact on effective e-learning. Hence, the guarantee of a stable infrastructure should be an essential condition for each partner.

**Identifying roles**

Table 6 presents the main roles stipulated in a collaboration agreement and the corresponding responsibilities.

<table>
<thead>
<tr>
<th>Role</th>
<th>Responsibilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coordinator</td>
<td>Provide general information&lt;br&gt;Ensure that the terms of the agreement are carried out&lt;br&gt;Facilitate communication between roles&lt;br&gt;Provide a report on final results</td>
</tr>
<tr>
<td>Academic manager</td>
<td>Manage the registration and enrolment process&lt;br&gt;Ensure that students have the appropriate background&lt;br&gt;Guide students</td>
</tr>
<tr>
<td>E-learning system manager</td>
<td>Provide technical support&lt;br&gt;Make necessary technical adaptations</td>
</tr>
<tr>
<td>Teacher</td>
<td>Prepare course materials&lt;br&gt;Develop the course&lt;br&gt;Manage online courses&lt;br&gt;Respond to students’ queries&lt;br&gt;Evaluate students’ work&lt;br&gt;Follow up on student feedback</td>
</tr>
<tr>
<td>Student</td>
<td>Use tools and resources&lt;br&gt;Participate actively&lt;br&gt;Interact with other students and teachers&lt;br&gt;Present assessments&lt;br&gt;Provide feedback</td>
</tr>
</tbody>
</table>
Business model

A business model can be defined as “an architecture for the product, service, and information flows, including a description of the various business actors and their roles; and a description of the potential benefits for the various business actors; and a description of the sources of revenues” (Timmers, 1999). Based on this definition and our educational scenario, we specify the potential benefits for the main actors (or roles) in a joint or double degree programme, which are detailed in Table 7. The Return on Investment (ROI) can be calculated by comparing the development cost of the new services for e-learning with its benefits.

Table 7. Potential benefits of a joint degree

<table>
<thead>
<tr>
<th>Actor</th>
<th>Benefits</th>
</tr>
</thead>
</table>
| University | Consolidate partnerships  
|          | Offer new opportunities  
|          | Improve and diversify knowledge  
|          | Gain prestige and reputation  
|          | Provide additional uses for educational content  
|          | Improve inter-university cooperation  
|          | Develop curriculum and sustainability  
|          | Internationalize the curriculum  
|          | Enhance the diversity of programmes  
|          | Enhance competitiveness in the educational market  
|          | Save time, money, and space  
|          | Enrich e-learning platforms  
|          | Reach new students  
|          | Strengthen academic research collaborations, and alliances  
|          | Promote collaboration and exchange  
|          | Increase usage of networks and services  
|          | Increase ROI  
|          | Expand into new markets  
|          | Diversify its faculty and staff |
| Teacher | Enhance intercultural experience  
|          | Enhance competitiveness  
|          | Provide opportunities for innovation in the teaching and learning process  
|          | Establish new courses with an international focus  
|          | Promote cooperation and exchange of ideas between teaching staff |
| Students | Improve opportunities and skills for employment  
|          | Access wide ranges of online resources  
|          | Stimulate the international employability of students  
|          | Provide intercultural experience  
|          | Enhance competitiveness in the labour market  
|          | Provide broader experiences  
|          | Provide opportunities to interact with international students  
|          | Improve foreign language skills  
|          | Provide flexibility, with 24/7 access to learning resources |

The development of joint degrees using e-learning systems allows universities to create new business opportunities. In this context, educational business processes are defined as a series of implemented services. Many institutions now view their curriculum and courses as capital. Some engage in for-profit, curriculum-based ventures, and others enter into strategic alliances “capitalizing on the curriculum” (Eckel, 2003). Based on this reasoning, we ask, why not capitalise on the electronic curriculum? If a university offers courses online, it can add value to its investment by being part of collaboration agreements to develop joint degrees. According to Eckel (2003), the curriculum may be conceptually considered as capital.

E-learning effects networking between universities in a global market. Traditional universities have the option of cooperating with other universities in developing course material and e-learning products. The sources of revenues
needed to participate in a joint degree are generated by e-learning course fees and reductions in commuting costs for teaching staff. We can identify four kinds of partner: paired domestic, European, transatlantic, and corporate partners.

A huge potential exists for combining these sources of revenue with economies of scale and the low provision costs that can be realised by offering e-learning services. The reusability of e-learning systems, or at least single system components, is an important aspect in implementing cost reductions. The number of potential users of e-learning systems increases by reusing system components (Breitner & Hoppe, 2005).

We propose to implement a service-oriented architecture that allows the easy adaptation of modules if business processes change over time. In this context, e-learning providers can model their business by selecting services as well as designing the services to be produced and their appropriate functionality. The following section presents the architecture proposed.

**Architecture design**

To facilitate the development of joint degrees through e-learning, a service-based architecture developed in accordance with the policies set out in the collaboration agreement is proposed. In this scenario, a joint degree can be defined as an academic program made up of a cluster of services that are offered by universities through their e-learning systems. These services offer support to academic and administrative processes, all of which are included in the academic program. The services are combined and federated in accordance with the agreement established by the universities involved (Aguirre, Quemada, & Salvachúa, 2008).

The services defined in existing e-learning frameworks are very useful in supporting typical e-learning applications. However, the development of a joint degree through these frameworks is not possible because of the lack of services to manage the joint curricula. Based on the aforementioned frameworks, we propose the design of a service-oriented architecture made up of an identity provider, service providers (e-learning systems), a policy editor, a policy manager, a workflow engine, and a service manager. This architecture will be federated by policies in accordance with the collaboration agreement signed by the participating universities (Aguirre, Quemada, & Salvachúa, 2010). The overall architecture is illustrated in Figure 4.
The identity provider is responsible for controlling the identity and validity of users. The service providers are responsible for publishing and offering services that allow access to other e-learning services. The policy editor enables the e-learning administrator to define policies expressed as sets of rules, which can be translated into policy language such as BPEL. In the same way, the policy editor allows administrators to define the process expressed as tasks. These policies and process will be sent to the policy manager. The policy manager is responsible for editing, storing, activating, deactivating, and deleting existing policies. Policies allow administrators to modify system behaviour without changing source code. Once the policies have been managed, the process, and policies are sent to the workflow engine, which is responsible for managing the federation and orchestration the process according to the policies. Each process is identified as a service. The workflow engine will enable and execute services in accordance with the information specified in the collaboration agreement (rules and process). The service information will be provided by the service manager. The service manager is responsible for identifying services that can be required in this scenario using context information stored in a database. The identified services are submitted to the policy manager, which will bind the services according to the policies specified in the agreement and the context information. In order to support the service federation, all educational services need to be registered in a central repository like UDDI.

The main difference between the existing e-learning frameworks and our approach is the inclusion of new services for supporting joint collaboration. Although the services that allow access to the courses will are available on different systems, they constitute a unique study plan.

**Implementing the model**

Based on the conceptual model presented in figure 3, the specification of objectives, resources, and terms of the collaborative agreement is the starting point. The implementation of a collaboration agreement in this context can be split into three layers: the business layer, the design layer, and the implementation layer. An example of objective of these layers is shown in Figure 5. The business layer specifies the terms of the joint agreement in plain language. The design layer identifies the necessary variables, rules, and tasks to satisfy the agreement. One or more rules are combined to form policies. The implementation layer invokes the services in each e-learning platform in accordance with the policies of the agreement. On this level, the composition, and orchestration technologies are carried out.

Once the document has been signed by the persons responsible for each partner university, the agreement must be translated into technical language. The translation process is carried out in the design layer, and the execution of services in the implementation layer.
The main tasks related by each role to the development of a joint degree are shown in Figure 6. These tasks are based on a collaboration program at our university and may vary with respect to different education systems. A clear assignment of tasks and responsibilities to each role should be carried out.

Each partner must ensure both the access to their e-learning system and the availability of all services needed to develop the joint degree. Each course specified in the agreement must be accessed through a service, which will be deployed according to the policies and context information. Therefore, each e-learning system manager has to make the necessary technical adaptations with the implementation of customized services.

A joint degree web page should be created in each institution host. It should contain the administrative support of the integrated program for students and teaching staff, course scheduling, and the integrated curricula which will be a list of courses linked to the corresponding e-learning system.

Students have to request admission and enrolment in each partner institution. Institutions can trust the management of users through an identity provider which will be responsible for controlling the identity and validation of users. It permits the support of Single Sign On in order to allow students to access an enrolled joint degree through any participating e-learning system. On the other hand, students should register in each platform.

In order to illustrate how the theoretical model can be tested, we describe a sample scenario in which only the terms of a collaboration agreement that can be implemented through e-learning have been selected.

![Figure 6](image)

*Figure 6. The main tasks to be implemented*
Sample scenario

Business layer

The summarized version of the agreement for this scenario is as follows:

“A) The University A (UA) from France and the University B (UB) from Spain agree to develop a joint master degree in Computer Science. B) The duration of the program is two years. C) The credit format is ECTS. In order to obtain the Joint Degree, the students have to study for a total of 120 ECTS credits. D) The curriculum approved by the universities involved is made up of: Course 1 (UA, 20 credits), Course 2 (UB, 20 credits), Course 3 (UA, 30 credits), Course 4 (UB, 30 credits) and 20 credits for the thesis at any participating university. A minimum of 60% is valid to pass a course. E) The language for instruction is English. F) Up to 15 students are to be accepted by each institution. G) The identification process will be federated through shibboleth, which will be located at http://jointdegree.shibboleth. H) This agreement will be in force for a period of five years starting from 20 July 2011”

Design layer

Based on this collaboration agreement, the e-learning manager will have to translate the agreement in terms of rules (policies) and tasks (services). Some rules and tasks identified for this example are detailed in Table 8.

<table>
<thead>
<tr>
<th>Terms</th>
<th>Rules</th>
<th>Tasks</th>
</tr>
</thead>
</table>
| A | Context: European | Set Name_degree: Computer science  
Set HostU: UA  
Set HostPartner: UB  
Search_DB_Context: European |
| B | | Set Duration: 2 years |
| C | | Set Credit_num: 120  
Set Credit_format: ECTS |
| D | A minimum of 60% is valid to pass a course | Set list_courses  
Enable_courses(list_courses)  
Register_courses(list_courses) |
| E | | Set Language: English |
| F | Up to 15 students are to be accepted by each institution | Set Total_students: 30 |
| G | Federated authentication | Set Id_provider: http://jointdegree.shibboleth  
Notify_providers |
| H | | Set Signature_date: 20 July 2010  
Set Expiration_date: 20 July 2015 |

Implementation layer

The rules and tasks identified above allow us to define the policies and services required to develop a joint degree managed by the execution of a workflow system. We can define a policy as a rule that defines the features of a service in terms of security, privacy, and implementation according to a set of conditions and context information. Figure 7 illustrates the sample scenario. Students enrolled in a joint degree can access it through any participating e-learning system.

Universities must ensure both the access to their e-learning system and the availability of all services and content needed to complete the joint degree. Therefore, the service “Register_course” must be executed by the e-learning managers to register each course at the service manager. The steps to register a course are: First, the e-learning manager, who is the only authorised role to execute this service, is logged in the e-learning system. Shibboleth will validate the user identity. Second, the request for the service “Register_course” is sent the workflow engine. Third,
the workflow engine checks if the policy manager has associated policies to this service. Forth, as a result of the service only can be executed by the e-learning manager role, the workflow manager must verify the user role with the identity provider. Finally, the course will be registered into the service manager. Considering that cultural aspects and website design have an intrinsic relationship, this service can use the context information to define the runtime environment (colour, styles, etc).

Figure 7. Sample scenario

Policies should be able to be updated during runtime by the e-learning system managers. The workflow supports processes based on a set of rules. Services management must be dynamic and adaptable to meet changing educational needs.

When a joint degree has been implemented, the academic manager, and coordinator must check whether the terms of the collaboration agreement have been fulfilled satisfactorily. Once a course has finished, the teacher will provide a report to the coordinator of the degree who will terminate the degree when all of the courses have been completed and the technical and academic reports finalised.

Conclusion

Joint and double degree programmes with international partners are becoming increasingly widespread. However, the lack of funding has become the most important barrier to advancing internationalization within institutions. An e-learning system can be adapted technically to support integrated programmes, to bridge national, international, and cultural issues and be used as an alternative to the very costly mobility of students.

The paper presents a review of the theoretical and technical issues on how e-learning systems can enable inter-institutional degree collaborations. We introduce a new domain of e-learning system. Joint degrees based on e-learning systems can be possible through automated composition of web services that can be implemented and
executed to fulfil collaboration agreements among academic institutions at national and international level. We have shown a theoretical model of developing new and innovative ways of promoting the internationalisation.

According to the key issues and limitations identified, most of the process of developing a joint degree through e-learning systems can be carried out, from the signing of the agreement to the implementation of the necessary services. Language and some cultural aspects related to web design can be managed through the implementation of context in services. However, some of the barriers to overcome in this scenario are: legal obstacles, national, and international recognition, quality assurance, the need for compatible credit systems, varying teaching approaches, examination procedures, the bureaucracy involved in the administrative processes, cultural differences, and bandwidth limitations. The administrative support in this context plays a crucial role, for this reason is important to develop a complete administrative support to ensure the success of this approach.

The economic crisis is having a marked impact on the internationalization process. E-learning can help to reduce these expenses, enhance the diversity of programmes and extend into new markets.

Legislation in each country should allow joint degrees to be established and recognised. In Europe, diploma supplements and the ECTS should facilitate this recognition process.

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References


Social Networks and Performance in Distributed Learning Communities

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ABSTRACT
Social networks play an essential role in learning environments as a key channel for knowledge sharing and students’ support. In distributed learning communities, knowledge sharing does not occur as spontaneously as when a working group shares the same physical space; knowledge sharing depends even more on student informal connections. In this study we analyse two distributed learning communities’ social networks in order to understand how characteristics of the social structure can enhance students’ success and performance. We used a monitoring system for social network data gathering. Results from correlation analyses showed that students’ social network characteristics are related to their performance.

Keywords
Social networks, Social capital, Knowledge sharing, Distributed learning communities

Introduction
Social capital refers to the stock of social trust, norms and networks that people can draw upon to solve common problems; it implies connections among individuals as well as the value accrued from these connections (Daniel et al., 2002). Usually when we think of what people use when seeking information about a particular subject, we think of databases, the Web, portals, intranets or more traditional sources such as books, encyclopedias, manuals or records. However, a significant component of information used by each person comes from his or her network of interpersonal relationships (Cross et al., 2001). Processes of production and use of knowledge are significantly influenced by the way knowledge is shared and disseminated through social networks. These sets of interpersonal relationships characterize the way a community or a working group develops its own activity. Social Network Analysis (SNA) techniques provide a rich and systematic means for assessing informal networks by mapping and analysing relationships among people (Cross et al., 2001) and can be a valuable analytical tool for examining complex social processes. Thus, SNA techniques raise the possibility of intervening at critical points within an informal network (Cho et al., 2007). Understanding the structure and dynamics of a community’s social network is essential in supporting the implementation of knowledge management strategies. An efficient management is the result of a process that requires understanding which parts have the capacity to create and extract, so that this value can be multiplied by the interaction and cross-fertilization of skills, fostering the flow and exchange of expertise (Edvisson & Malone, 1999). There is abundant cross-sectional evidence of performance correlated with network structure (Burt & Ronchi, 2007). Efforts to strengthen connections or to reinvent organization structure in order to increase the likelihood of strategic success should be based on network information. By revealing organizational trends and identifying the most influential individuals, the network information prevents duplication of efforts and facilitates the distribution of investment among various stakeholders (Clark, 2006; Hoppe & Reinelt, 2009).

Social networks also play an essential role in learning environments as a key channel for knowledge sharing and as a source of social support. Learning activities involving group work and collaboration promote learner-to-learner interactions in order to support the co-construction of knowledge and the sharing of information and resources (Dawson, 2008). Traditional instructional design will continue to be important, but additional emphasis on diverse multifaceted networks needs to be placed to address both the way knowledge exists in networks and the way learning develops and forms (Siemens, 2008). From a social perspective, learning is a social and collective outcome achieved through seamless conversations, shared practices, and networks of social connections (Cho et al., 2007). While learners are doing a learning task or activity, they usually look for some knowledge through their informal networks of colleagues and friends. For most people it is much easier to ask for help from a friend or close colleague than an expert in the area who is totally unknown (Braun et al., 2007). Usually they choose not to go to the channel of the highest quality of information, but rather to go to the channel of the highest accessibility (El-Bishouty et al., 2010). It is therefore expectable that social network structure may explain what makes some individuals or groups more
creative and effective in their use of knowledge than others, and hence that social network position and structure are related to students’ success and performance.

The aim of this work is to investigate the relations between social networks and students’ performance in two distributed learning communities. When a learning community is geographically distributed, opportunities for the learner to engage with peers in a collaborative environment are problematic given the lack of spatial and temporal requirements associated with traditional classroom settings (Dawson, 2008). In these contexts, it is even more pertinent the concern for a social structure that supports an environment of sharing and collaboration, since knowledge sharing does not occur so spontaneously as when a working group shares the same physical space (Gutwin et al., 2007; Zheng & Yano, 2007). In order to better understand social capital and how social network could be related to the outcomes, we analysed the role that social network structure can have on students’ performance. Descriptive information on the communities’ social network is presented and the correlations between students’ social network characteristics and students’ performance are analysed.

Social Network Structure and Performance

Knowledge is created and exchanged to a large extent through informal social interactions (Cross, et al., 2002; Storberg-Walker & Gubbins, 2007; El-Bishouty et al., 2010). In addition, the knowledge flows depend on the connections between individuals and on their attitude about sharing knowledge (Inkpen & Tsang, 2005; Ipe, 2003). Informal networks are based on spontaneous contacts, by self-initiative and self-motivation and evolve according to mutual trust, reciprocity and friendship grow (Wang & Yang, 2007; Lin, 2007). The physical proximity, frequent contact, similarity of languages, knowledge and experiences as well as beliefs and attitudes, facilitate knowledge sharing (Novak & Wurst, 2005). Informal networks also play a key role in facilitating coordination and avoiding potential conflicts (Garcia-Perez & Mitra, 2007).

Social network analysis is frequently applied in a knowledge management perspective with the purpose of helping organizations to better take advantage of the knowledge and capabilities distributed across its members (Borgatti et al., 2009). Burt (2009) highlights two facts that were revealed by SNA empirical research: 1) people tend to cluster, forming groups according to their respective institutions, projects in which they are involved, sharing of physical spaces or common interests, 2) the interaction is much more common within a group than inter groups, so people in the same group tend to have the same ideas and opinions, to interpret the past in the same way and to have similar expectations for the future.

Although there is interest in network antecedents, the primary focus of network research has been on the consequences of networks (Borgatti et a., 2009). It is believed that individuals with fewer constraints and more opportunities are those that are in favorable positions in the social network (Hanneman & Riddle, 2005). Network position might also provide an ability to help absorb knowledge acquired elsewhere (Cross & Cummings, 2004). Sparrowe et al. (2001) showed that individual job performance was positively related to centrality in advice networks and negatively related to centrality in hindrance networks composed of relationships tending to thwart task behaviours. In a study involving managers and highly skilled professionals, Song et al. (2007) found associations between centrality with creative and efficient use of knowledge. At a group level, researchers tended to emphasize variation in social structure across different groups, using these variations to explain differences in outcomes (Borgatti et al., 2009). Cohesive and closed networks might promote a trust and well-known environment that enables knowledge sharing. However, closed networks might also have unintended consequences in performance if they result in comfortable interactions but do not allow gathering the most relevant knowledge for the task at hand (Cross & Cummings, 2004). Reagans and Zuckerman (2001) found out that R&D teams with higher productivity were those with higher heterogeneity and higher social network density. Creativity and innovation are facilitated by an easy access to diverse and non-redundant information and the heterogeneity of network is positively associated with strategic and creative results. Moreover, these authors have shown that social cohesion, measured by the density of relationships, affect the willingness and motivation to share knowledge, and hence productivity. Sandstrom and Carlsson (2008) showed that closure and team heterogeneity were related to performance measured in terms of efficiency and innovativeness. Hansen (2002), working with different units and project teams of a large multinational, confirmed the correlation between highly connected teams and their efficiency in knowledge sharing.
Centrality metrics measure the extent to which a given individual is connected to others in a network. Degree centrality refers to the extent to which an individual has numerous connections to other members, reflecting his or her level of social activity. Individuals who exhibit high values of degree tend to occupy prominent positions characterized by intensive interactions and knowledge sharing activities (Song et al., 2007). Because of their numerous connections to others, central individuals have more relationships to draw upon in obtaining resources and so are less dependent on a limited number of individuals (Hanneman & Riddle, 2005). Individuals with fewer contacts mostly occupy peripheral positions with little access to communication and information (Song et al., 2007). Degree centrality is related to reciprocal links (Ahuja & Carley, 1999), access to tacit knowledge (Hansen, 2002), and had been positively associated with performance (Sparrow et al. 2001; Hansen, 2002; Song et al., 2007; Cho et al., 2007). Given these arguments we decided to explore the association between degree centrality and student’s performance, and hypothesis H1 was tested:

H1. The greater the number of a student’s contacts, the greater the student’s performance.

Closeness centrality reflects the individual’s distance to all others on the network. While degree centrality measures only the direct contacts of an individual reflecting what is happening locally, closeness translates the individual's position compared to the entire community (Hanneman & Riddle, 2005). Closeness centrality is associated with proximity and close relations that foster a trusting environment, which facilitates the sharing of resources and tacit knowledge (Hansen, 2002). People that have direct links or shorter distances to all others become aware of opportunities earlier than those with longer paths (Song et al., 2007). The probability of information distortion and unawareness about what is happening is high when indirect relations are involved. Closeness centrality has been associated with efficient knowledge sharing and better performance (Ahuja & Carley, 1999, Song et al. 2007; Sandstrom & Carlsson, 2008). In this study, we tested the possible association between closeness and performance:

H2. The smaller the distance of a student to all others, the greater the student’s performance.

Betweenness centrality captures the property of frequently lying along the shortest path between pairs of persons. Higher values of betweenness are associated with opportunities and power in the sense that one individual can control and change the communication flow passing through in order to better serve their own interests (Hansen, 2002; Borgatti et al. 2009). People occupying these positions constitute access bridges for those who are not directly connected and also benefit from access to a wider and more diverse source of resources, knowledge and experience (Tsai & Ghoshal, 1998; Cho et al., 2007). Higher values of betweenness are also associated with the ability to obtain and apply relevant information to solve problems effectively and efficiently (Cross & Cummings, 2004). Several studies associated empirically betweenness with performance (Tsai & Ghoshal, 1998; Cross & Cummings, 2004; Burt, 1997 and 2005, Song et al., 2007) which yields in the following hypothesis:

H3: The higher the student’s level of interconnection among others, the better the student’s performance.

**Method**

**Participants**

We conducted our research with two different distributed communities: 1) the Multimedia Engineering PhD Programme of Polytechnic University of Catalonia, Spain (UPC); and 2) the Basic Education Distance Learning Course of Polytechnic Institute of Leiria, Portugal (EB).

The UPC community is a multidisciplinary group of sixty two researchers, including fifty two PhD students. In this community, multimedia engineering projects and services rely upon multidisciplinary teams that bring together different expert knowledge domains (engineers, designers, teachers, mathematicians, anthropologists, psychologists). There is a central unit of 21 people located in Barcelona, Spain, but the rest of members are geographically distributed through several countries (Venezuela, Mexico, Colombia, Portugal, Denmark, and USA) and primarily maintain virtual interaction with others. This community uses a web platform for information sharing and there are weekly seminars (virtual conferences) for individual and group research presentations. Most communications occur outside this platform through e-mail, chat, or, in some cases, face-to-face encounters.
The EB community includes nineteen students and five teachers and uses a learning managing system (LMS) for daily course activities. This is also a geographically distributed community with most student-teacher interactions occurring in the LMS. Student-student interactions occurred mainly through e-mail and chat. All the community has face-to-face meetings at least once a month for work presentations and individual evaluations.

Data Collection

Social network data. To collect data we used a social network monitoring system – KIWI (Knowledge Interactions to Work and Innovate). KIWI is a web-based application with two separate views: one for data collection and other for feedback. The system provides users with a gathering tool for registering their interactions and automatically analyses and presents social network information through a visualization tool. Explicit social network information is extracted from a database through social network analysis (SNA) techniques. This system was developed mainly to be applied in distributed communities (for more information, see Cadima et al. 2010) and depends on active participation of users in the data gathering process. In addition to its potential to go further in a systematic analysis of social network by researchers and community managers, the system supports social network awareness of users by making the hidden networks visible to all community, without abstracting or evaluating users’ behaviours. By directly asking users about their interactions it is possible to monitor every kind of interaction, from face-to-face meetings to mail and chat interaction, without implying major changes to users' current behaviour (the imposition of new communication tools could change the existing spontaneous informal network and would not ensure that all of what was happening was being recorded). Although the required involvement in the data gathering process creates additional workload for users, potentially leading to a disparity between effort and benefit (Van Baren et al., 2004; Rittenbruch et al., 2007), we note two advantages of this strategy. First, this option can act as a filtering strategy which will increase the extraction of meaningful information and decrease the burden in analysis, instead of producing extensive data as most monitoring systems do, which in turn would require considerable effort to uncover significant relationships within the group (Chen et al., 2003). Second, this strategy is likely to promote individual responsibility, to strengthen trust among participants, and to improve self-awareness, self-direction and self-management of their own activities (Zheng et al., 2007).

In attending to map social network structure, the system was integrated into communities’ web platforms and a field test was conducted in each community. Participants were asked to respond to KIWI data gathering tool every week, identifying those people with whom they interacted for advice and knowledge sharing during that week. Participants were explained that every meaningful interaction should be point out, including formal or informal communications and face-to-face or distance communications. A weekly e-mail was send reminding participants (including students, teachers and directors) to access KIWI and their accesses were monitored. In UPC community, the system was used during an 18 weeks period and in EB community it was used for an 8 weeks period. From the social networks data generated, we computed degree, closeness, and betweenness centrality scores for each individual using Ucinet (Borgatti et al., 2002) and NetDraw (Borgatti, 2002). In both communities, social networks that were considered include everyone in the community and therefore the computed measures for students take into account the links students-students and students-teachers or students-directors.

Performance data. In evaluating students’ performance we used separate instruments for UPC and EB communities given the distinct objectives and working methods of each community. In UPC community, individual performance was assessed by directors using seven items tool developed by Sparrowe, Liden and Kraimer (2001) on a scale ranging from “very poor” (1) to “very rich” (5). Items addressed the quality and quantity of work and the initiative, cooperation, timeliness, and overall performance. A total of forty six students were assessed, with internal consistency of $\alpha = .96$. In the EB community, individual performance metrics were obtained from students’ grades at the four curriculum units they attended during the eight weeks of the field test. The social network monitoring system has been used from the first week of activities until the last week of final evaluations. According to Chen et al. (2003) these ratings are a good indicator of individual performance in computer supported collaborative learning (CSCL) contexts. An average grade was computed for fifteen students, with internal consistency of $\alpha = .72$.

In both communities, correlation analyses between network characteristics and performance were applied to a students’ group.
Results
Social Networks

During the field test, participants were asked to register their both formal and informal interactions in order to map social network structure. The individual mean average in UPC community was 6.8 interactions by person by week (SD = 4.4). Figure 1 displays the connections registered by the sixty two members of UPC community during the eighteen week field study, and include directors (triangles), advanced students (squares) and beginning students (circles). Colours are used to identify distribution among countries: people from Spain are in red, from Portugal in black, from Venezuela in blue, from Mexico in grey and people from other places (USA, Denmark, and Colombia) are in pink.

The network diagram of UPC community shows a cohesive network (density = 0.191) with no isolated subgroups except a single individual (he answered KIWI gathering tool several times informing that there were no interactions). The average distance between people was 1.973, reflecting that most people were just one person apart. Inside community, there were distinct levels of activity, with individual’s network size varying from 0 to 50 contacts. Above 25% of community’s members had more than 15 people in their individual network, and other 25% of members had less than 3 people in their individual network. Directors (triangles) were in network centre and showed highest degrees of interaction with a mean average of 21.2 contacts. If we only consider the connections between students, the density of this sub-network decrease to 0.125, showing that directors have a major role in connecting students across all community.

In the EB community, the individual mean average was 7.78 interactions by person by week (SD=3.24). Figure 2 displays the social network registered by the twenty four members during the 8 week field study. Teachers are represented by blue squares and students by red circles.

The network diagram shows an extremely cohesive network (density=0.638) with an average distance between people of 1.362, reflecting a great proximity between people. Individual’s network size varies from 4 to 23 contacts, revealing a wide range of behaviors. The average number of individual’s contacts is 13.42 for students and 19.25 for teachers. Considering only the connections between students, the density of students’ sub-network is 0.491. This
shows that, despite the higher teachers’ number of contacts, students’ sub-network continues being an extremely cohesive structure.

Associations between network centrality measures and individual performance

Descriptive statistics and correlations among study variables in respecting to each community students’ group are reported in Table 1. We found out positive associations between degree centrality and individual’s performance, with coefficients of .62 (p < .01) for UPC group and 0.57 (p < .05) for EB group. These results support the first hypothesis under study, confirming that in both communities studied, the greater the number of contacts of a student the better is his or her performance.

Regarding the relation between closeness centrality and performance, the results show negative associations with coefficients of -.67 (p < .01) for UPC group and -.57 (p < .05) for EB group. These results indicate that the shorter the distance of one individual to all others in community, the better is his or her performance, giving support to second hypothesis under study.

| Table 1. Descriptive statistics and correlations for study variables in students’ groups |
|---------------------------------|--------|--------|--------|--------|--------|--------|
|                                 | Mean   | SD     | 1      | 2      | 3      | 4      |
| UPC (n=46)                      |        |        |        |        |        |        |
| 1. Degree                       | 10.43  | 6.50   | 1      |        |        |        |
| 2. Closeness                    | 750.65 | 14.47  | -.87** | 1      |        |        |
| 3. Betweenness                  | 14.82  | 28.51  | .56**  | -.37*  | 1      |        |
| 4. Performance                  | 2.95   | 1.25   | .62**  | -.67** | .23    | 1      |
| EB (n=15)                       |        |        |        |        |        |        |
| 1. Degree                       | 14.27  | 4.33   | 1      |        |        |        |
| 2. Closeness                    | 55.73  | 4.33   | -.1**  | 1      |        |        |
| 3. Betweenness                  | 2.89   | 4.23   | .70**  | -.70** | 1      |        |
| 4. Performance                  | 12.23  | 2.38   | .57*   | -.57*  | .17    | 1      |

** p < .01; * p < .05.

Results did not support our third hypothesis which stated that betweenness centrality is positively related to individual performance, unlike referenced by some studies (Tsai & Ghoshal, 1998; Cross & Cummings, 2004; Burt, 1997 e 2005; Song et al., 2007). Apparently, in these two communities, the fact that an individual is occupying a more central role in the interconnection among others has no relation with his or her performance.

Conclusions

Our work led us to some interesting results showing that in the two distributed learning communities there were significant correlations between the social network and students’ performance. This indicates that some students were structurally advantaged or disadvantaged as a result of their network positions. Through the correlation analysis between centrality metrics and individual performance, it was possible to verify the association between degree centrality and performance, revealing that the greater the number of contacts of an individual, the better is his performance. It was also possible to verify the significant association between closeness centrality and performance, which reveals that the shorter the distance from one individual to all other individuals in the community, the better is his performance. We found no relation between an intermediation position among others and individual performance which may be due to the high cohesion and density of both communities’ networks.

These results seem to confirm the relevance of using these metrics for supporting knowledge management and make a contribution to the clarification of the concept of social capital in this type of communities. Despite the great amount of distance communication existing and although the distinct objectives and working methods of each community, results showed that social structure is related to performance. Social network analysis can be conducted as a means to identify and understand emerging social structures and collaborative patterns, which in turn might give helpful clues to managers and teachers, allowing them to act and propose different strategies when trying to redesign social infrastructures in distributed learning communities. We also believe that this kind of information about social network could be a powerful tool to students. Based on Burt and Ronchi (2007) field experiment, in which the
performance of the executives educated in the network structure of social capital showed to improve in comparison to a control group, it is possible that enhancing students’ awareness about social structure can have potential effects on their performance.

Limitations

This study has some potential limitations that should be acknowledged. The first concerns the validity of our performance measures. In EB community we use formal grades that may not represent comprehensively the student’s performance and his/her contribution to community, such as the degree of initiative and cooperation. Odelius and Santos (2007) argue that an evaluation process of individual’s performance, which they see as the measurement of aspects of individual’s competitiveness, effectiveness, efficiency and skills, should be conducted assessing gains for the individual and the organization. Moreover, in addition to meeting the gains in productivity, this assessment should also consider the prospect of personal and professional growth. In UPC community performance’s measures could be distorted if director’s perceptions were inaccurate and although performance ratings data had different sources, aspects of the social context may have biased the subjective evaluation of performance.

Another limitation that deserves to be pointed out concerns the fact other variables that could influence social networks’ structures and patterns were not included. Subjects’ attributes and characteristics, such as students’ context activity, being full or part time student, training bases, or number and type of projects, may eventually influence social network’s position and student’s performance. Moreover, according to Cross and Cummings (2004), in knowledge intensive work contexts, interactions with the outside community are positively related to individual performance, however interactions with the outside were not considered in this study. Further research considering a wider set of variables is needed in order to assess which characteristics could have an important role in social network structure and could be related to performance.

Although we worked with two communities with different structures and different working styles and objectives, we are also cautious in attempting to generalize findings to other settings where social dynamics and structures may be significantly different. The absence of a relation between betweenness centrality and performance, unlike referenced by some studies (Tsai & Ghoshal, 1998; Cross & Cummings, 2004; Burt, 1997 e 2005; Song et al., 2007), despite it may be due to the high cohesion and density of these two communities’ networks, deserve future and deeper research. We emphasize that findings and implications of this study should be further tested and validated by future research employing samples in different contexts.

References


A Framework for Simplifying Educator Tasks Related to the Integration of Games in the Learning Flow

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ABSTRACT
The integration of educational video games in educational settings in general, and e-learning systems in particular, can be challenging for educators. We propose a framework that aims to facilitate educators’ participation in the creation and modification of courses that use educational games. Our approach addresses problems identified by previous experiences with games in educational settings, including assessment of learning outcomes and student tracking. Our framework has been implemented following an application model that takes advantage of pre-existing systems: the <e-Adventure> educational video game framework and the Learning Activity Management System (LAMS). This approach has been put into practice in a case study carried out in a primary school, covering from the design of the learning experience to the development of the educational games and the deployment and evaluation with students, involving the educators actively and gathering their perceptions. The first impressions expressed by the educators support the potential of the framework in terms of the students’ assessment and the personalization of the lesson. Although educators pointed out the difficulty of creating games from scratch, they appreciated the easiness of introducing existing games in their courses and adapting them to their specific educational settings.

Keywords
Game-based learning, game-authoring tool, educational sequences, general games’ integration framework

Introduction

In recent years, much research has been carried out in the area of digital game-based learning. Different authors have identified multiple features in digital computer and video games that can be used to address some of the challenges that educational systems face (Aldrich, 2005; Gee, 2003; Squire, 2003). Video games promote intrinsic and extrinsic motivation (Garris, Ahlers, & Driskell, 2002) and producing optimal flow experiences (Chen, 2007). Although their effectiveness to improve students’ performance is still under discussion (Hays, 2005), recent studies show that games can increase: (i) student engagement during instruction (Annetta. Minogue, Holmes, & Cheng 2009); (ii) academic achievement in different domains (Blunt 2007); and (iii) skills, knowledge, and attitudes, especially in the right environment and context (Pivec & Pivec 2008).

Therefore the discussion should also begin to consider educational and implementation issues related to the effective integration of games in the curricula, like the lack of alignment to educational standards or the availability of the appropriate equipment (e.g., up-to-date computers) (Rice 2007). In addition, the introduction of video games in the learning flow can be disruptive for educators. Games are a new medium, where educators face up to various challenges: aligning games with curricular objectives and pedagogical foundations (especially in formal education) (Van Eck, 2006), and evaluating the learning experiences with games (de Freitas & Oliver, 2006; Hays, 2005).

This paper focuses on how to facilitate the integration of video games into educational settings while at the same time minimizing disruption caused by the use of new technologies. The long-term goal is to support the integration of games in broader courses where they can coexist with other materials, minimizing the impact on the educators’ workload. We present a framework that aims to address this goal by providing educators with three main tools: a) assessment of the learning outcomes and tracking student activity in the game; b) connecting assessment data with other learning activities to adapt the learning flow; and c) reuse of successful teacher-created courses that combine games and other educational materials throughout the community.
We also propose a specific implementation with an application model that takes advantage of two pre-existing e-learning tools: the Learning Activity Management System (LAMS) e-learning platform (Dalziel, 2003) and the <e-Adventure> educational gaming platform (Torrente, Moreno-Ger, Martinez-Ortiz, & Fernández-Manjón 2009). A case study was set in a primary school setting in order to gather educators' first impressions about the potential of the framework.

This paper is structured as follows: First we set the motivation for this work by analyzing the main barriers posed by the application of educational gaming in educational settings. Secondly we introduce the framework and the application model in separate sections. Then we describe the case study and finally discuss our conclusions and describe future lines of work.

**Applying video games in education**

A common approach to using games inside the classroom is the use of COTS (Commercial Off-The-Shelf) computer games; that is, games that were produced for leisure but offer potential educational value. Squire (Squire, 2003) reported experiences where Civilizaton III was used in K-12 history courses. More recent examples include the use of games like the Tycoon sagas (Sandford, Ulicsak, Facer, & Rudd, 2006), action games (e.g., Delta Force) adapted for military training (Fong, 2006), or multiplayer role games as World of Warcraft (Dickey, 2011).

In these cases, the games are used as published, giving educators little control over the process or support to track students’ interactions to effectively evaluate students’ performance. Some researchers use post-game debates, debriefing sessions, or simply observe students’ interaction with the game to establish the outcome from the video game (Squire, 2005). Although such activities can be beneficial, they can also be difficult to manage when the number of students is high (Egenfeldt-Nielsen, 2004) and require excessive dedication from the educator. Furthermore, authors like McFarlane et al. (2002), have pointed out the complexity of linking game objectives and contents with those presented in the curricula. This complexity arises partly from the difficulty in foreseeing learning outcomes in commercial video games (Gee, 2003). As a consequence, the skills and knowledge acquired by students may differ from educators’ planned learning outcomes and goals (Sandford et al. 2006).

In contrast to using COTS games, Van Eck (2006) considered the design of educational games where educators and game designers collaborate. The first games developed specifically for education dates back to the 70s. One example is The Oregon Trail, an adventure role-playing game developed to teach students about the 19th century colonization of the west of USA (Wesley 1974). A more recent title is NanoMission, a set of games for nanotechnology teaching covering different aspects from nanomedicine and nanoelectronics to quantum theory and quantum computing (Milburn 2010). However, the high cost of developing games from scratch makes this approach less feasible, costing around 20-100K dollars per learning simulation & game as reported by the eLearning Guild in 2008 (Wexler, Corti, Derryberry, Quinn, & Barneveld, 2008). Hence, there is a growing need of producing and sharing game-based educational content that is reusable.

Other experiences depict a more holistic approach, where the environment in a game is enhanced with tools that help educators to monitor and control the game experience. That is the case for 3D Multi user virtual environments (MUVEs) like Quest Atlantis (Barab, Thomas, Dodge, Carteaux, & Tuzun, 2005) or River City (Ketelhut, Dede, Clarke, & Nelson, 2006), where the game interface also embeds tools to facilitate communication, review of the students’ achievements and the assignment of goal-oriented tasks to the students. These systems are usually built upon the idea that it is not only the game what promotes learning, but also its environment (Pivec 2009). In this sense, issues such as the role of the educator, how the game is integrated in the curricula, or how the informal learning that occurs when students collaborate and discuss about the game enhance the educational value. This is related to the idea of games considered as an additional activity that is not isolated but linked to other activities and contents, and where the game’s outputs can influence the development of the learning process. However, it is still an open research question how to design educational experiences that successfully include games, as the number of studies in this regard is still scarce.
A framework for video game integration

We propose a framework to help educators in integrating video games in education, assuming that games will be used as learning activities that are part of larger designs. The framework’s is built on the following objectives:

- Defining the goals/learning objectives and measuring the learning outcomes for game-based learning activities.
- Adapting (on-the-fly) the learning experience for each individual student using the game’s outcomes (data inferred from game/student interaction).
- Fostering the reuse of successful pedagogical approaches in learning designs that use games.

These objectives aim to reduce the impact on the educator by balancing the overhead and the educational benefits obtained from the integration of educational video games in learning designs.

Defining the goals and measuring the learning outcomes for game-based learning activities

To facilitate the alignment of the learning objectives with existing curricula, we propose to design games with well-defined learning objectives and short expected completion time (around 15-45 minutes on average). This facilitates the design of game mechanics that focus on addressing a single goal (or a small set of goals) proposed for the activity. Short games also facilitate development and maintenance, as well as an easier integration with existing curricula (Dickey, 2005), and align better with the ideas behind the Learning objects model. When the objectives are numerous, more games or complementary content can be developed, instead of making the game longer.

The extraction of user interaction information is necessary for exploiting the potential of games as assessable and adaptive content (Moreno-Ger, Burgos, Martínez-Ortiz, Sierra, & Fernández-Manjón 2008; Peirce, Conlan, & Wade, 2008). The games should be powered with interaction tracking capabilities to exploit the high amount of valuable information that can be gathered from the games for assessment purposes. However, not all the information that a game produces is useful from an educational perspective. We propose to make available an assessment mechanism to filter the tracking information according to educators’ criteria, thus allowing them to decide the level of detail and the kind of information to extract from the game. Developing games with clearly identified learning objectives powered with tracking information capabilities would alert educators about deviations from the desired goal.

However, this level of analysis may be, in some situations, too abstract or require a deep knowledge of the game’s internal structure. We propose to focus in a set of predefined assessment criteria and data that could be used by educators with little experience with video games, improving their understanding of the game outputs. This basic dataset is only a baseline model, designed to be extended with the assessment mechanism when more detailed information is required. The values in this dataset are global score, game completion status, total time and play time (see Table 1) (Del Blanco, Torrente, Marchiori, Martínez-Ortiz, Moreno-Ger, & Fernández-Manjón 2010). Some interesting information can be expressed combining these values, for example if the main objectives of the game were achieved or not, the level of achievement and the time spent in this task.

<table>
<thead>
<tr>
<th>Data point</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Global score</td>
<td>Score obtained by the student for the global objective of the game. This value can be internally obtained by combining the values of each single objective.</td>
</tr>
<tr>
<td>Game completion</td>
<td>“Yes” if the student completed the whole game, “No” if he/she quit before completing the game.</td>
</tr>
<tr>
<td>Total time</td>
<td>Time passed since the student enters the game until she/he completes the game or quits.</td>
</tr>
<tr>
<td>Play time</td>
<td>Actual play time. It is calculated by subtracting the time the game was paused from the total time.</td>
</tr>
</tbody>
</table>

Adapting the learning experience for each individual student using the game’s outcomes

In the adaptive educational experiences, the outputs of some of the activities can be used as inputs in others. This approach results in learning flows that can be adapted during the execution of the learning experience (Hannafin, Hill, & Land, 1997). This way, considering games as a new learning activity type and using the tracking and
assessment outputs gathering during in-game-play, games should modify the course flow accordingly. Setting up a scenario where game-based activities are part of larger designs that combine different activities requires the educator to consider assessment data collected throughout the whole learning process.

The combination of games with other contents and tools can provide educators with further control mechanisms over the learning flow by considering the information gathered from both the game and other activities in the lesson design. This approach can provide educators with a powerful tool for adapting the flow of the educational session at any point, either during the lesson development or while the course is being executed. For example, educators could define conditions over the outputs of the activities and drive the learning flow through different paths, depending on each individual’s achievements. If the learner underperforms in the game, additional contents and examples are provided as reinforcement.

**Fostering the reuse of successful pedagogical approaches in learning designs that use games**

We identify as a key aspect for the advancement of the field the existence of mechanisms that facilitate sharing good practices in pedagogical approaches with games among the educators’ community. There should be a repository in the learning community where not only the learning designs with games but also games themselves can be shared including some relevant educational information (e.g., learning objectives, target students). Besides, the game internal elements (i.e., design, tracking model) should be accessible allowing future educators to understand and modify the in-game objectives and assessment. In the same way, there should be a mechanism that allows identifying and changing the learning designs defined using the game outcomes.

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*Figure 1. Workflow for video game integration in the learning flow*
Our framework highlights the importance of providing mechanisms that facilitate as much as possible the repurposing or reutilization of learning designs that combine games with other activities. On one hand, the simplified dataset allows a better understanding of how assessment works within an existing game and the game’s role inside the educational lesson.

In summary, games offer new opportunities for education but, at the same time, they can be disruptive and require additional work. To simplify the use of video games in educational environments, it is necessary to reduce the technical barriers related to several problems such as game delivery, assessment of game learning outcomes, and its connection with other course activities.

**Game integration workflow**

The objectives presented above can be combined in a workflow for video game integration (Figure 1) in which educators design their own courses leveraging existing content, and deploy adaptive learning experiences that can be tracked and modified during their execution. The Figure 1 shows the three different phases during in video game integration: lesson development, lesson execution and post-lesson execution.

This workflow is conceived as cyclical process where the mechanisms on which the framework is built on, are used to:

- Modify the lessons/games existing in the repository or create games.
- Adapt the lessons both automatically and on the fly using the game outputs.
- Gather the assessment reports and, if the educator finds some weak points in the lesson, modify the lesson accordingly.
- Share the lesson with the community.

It is difficult for educators to develop their own interactive contents due to time and workload constraints. The educators’ role in video game integration is in most cases restricted to understanding how to better employ games in their learning designs. Content and lesson providers are responsible for feeding the repositories with new games/lessons and educators can contribute with their modifications over the created ones.

**Application model**

The objectives proposed in the framework so far require a solid environment to develop and execute lessons that supports the described mechanisms for tracking and adaptation features, and a game platform with assessment data reporting and in-game objectives identification. Besides, the application model should deal with delivery problems that arise in the online distribution of video games and be able to establish communication links to exchange information (Burgos, Tattersall, & Koper 2007).

The application model is built using two e-learning platforms that meet both pedagogical and technical requirements: the Learning Activity Management System (LAMS) as a back-end, and the <e-Adventure> gaming platform, which includes reusable communication and assessment facilities and game objectives definition.

LAMS is an e-learning solution that facilitates the creation and execution of designs for the course. LAMS is inspired by the IMS Learning Design specification (http://www.imsglobal.org/learningdesign/index.html) and its ancestor, the Educational Modelling Language (Koper & Manderveld, 2004) where the concept of activity appears as the minimal meaningful unit in the sequence of contents. LAMS provides a mechanism to control and track the student’s performance in some of the included activities (e.g., Multiple Choice activity). Using the data gathered, LAMS allows defining a complex control over the sequence’s flow either at lesson authoring or during the lesson execution. The educators can follow the lesson execution in a specific view where they can monitor the students’ progress. Also, LAMS fosters the reutilization and repurposing of learning designs by a mechanism to export/import the learning sequences to external repositories.
<e-Adventure> is an authoring platform created with the aim of facilitating the development of 2D educational video games and simulations, enhancing their educational value and simplifying the participation of educators in the development process. The most relevant educational features in <e-Adventure> in regard to this work are the possibility to easily deploy games in a wide range of popular Learning Management Systems using common specifications and standards from the e-learning field (Del Blanco, Torrente, Moreno-Ger, & Fernández-Manjón 2010) and the mechanism that allows for the extraction of an assessment report on the students’ progress (Moreno-Ger et al. 2008).

In their last official releases LAMS (v.2.3.5) and <e-Adventure> (v1.3) have been extended with a new type of activity to integrate <e-Adventure> games into LAMS sequences (Del Blanco, Torrente, Marchiori, et al. 2010). In relation with the main objectives of this paper, the combination of <e-Adventure> games and LAMS allows educators a deeper control over the game experience inside an educational course.

Using <e-Adventure>, game authors can identify the objectives as the game states and filter the information that will be appended to a human-readable report and/or sent back to LAMS as attribute-value pairs. This way, an educator can define and link in-game objectives with game outputs. <e-Adventure> implements the predefined assessment dataset previously described that can be easily extended creating new variables and values to be exchanged. With the <e-Adventure> activity in LAMS it is possible to enable an active communication between the games (in the students computer) and LAMS (in a central server) to gather the assessment information.

Moreover, educators can use an <e-Adventure> activity like any other LAMS activity for monitoring and flow control tasks. On one hand, educators can define conditions taking into account the values returned by the game for automatic flow control. On the other hand, during the execution of the activity sequence, educators can access the assessment reports produced by games and, if necessary, modify the sequence flow.

Finally, the combination of the two platforms provides new ways to exchange and reuse designs of educational courses that include games using the exportation/importation features of LAMS. LAMS provides a learning repository (http://lamscommunity.org/lamscentral/) to share learning designs and <e-Adventure> has a repository (http://e-adventure.e-ucm.es/repository) to share educational games. Taking the underlying design of the educational session as a basis, educators can adapt not only the sequences (sequence flow, available activities, etc.), but also the games themselves (e.g., modify the learning objectives, adapt the language of the game to the local requirements, add/remove game elements or personalize the assessment system).

Case study

We conducted a case study with primary education students in the Ramiro de Maeztu School, a K-12 institution in Madrid (Spain). The aim of the case study was to gather insight about the applicability of the framework proposed using a particular technical solution. Therefore, the main objective of this experience was to establish the feasibility of the creation and execution of an adaptive lesson using games by educators without experience in games and to examine their perceptions about the usefulness of the approach. In close collaboration with educators from the institution, we developed an educational session in LAMS covering the mathematical concept of parity, including two different versions of an <e-Adventure> game created for this experience. The target audience was a group of 6 year old students. Educators provided the educational session design and all the pedagogical support for the development of the educational game.

Two aspects were mainly under evaluation:

- The applicability of the framework in a real educational context and educators’ perceived usefulness.
- The value of the assessment features of the proposed framework in terms of potential (i.e., ability to extract a reliable measurement of the students’ achievements) and cost (i.e., ease to define and gather the assessment information required).

The experiment was performed with a group of 26 students. During the lesson execution two researchers and one educator were present during the session to assist the students with the usage of the system. No help in solving the challenges proposed in the course was provided. An analysis of the assessment data gathered during the experience...
was performed through the monitoring capabilities of the LAMS environment. Educators could track the progress of each student within the sequence, both during the lesson execution and when the lesson finished, including the activities that each student had already executed, the time spent on each activity, and the assessment report about their interaction with the video game.

Lesson development

The design of the educational session targets two main objectives: (1) to acquire the concepts of odd and even; and (2) to recognize odd and even numbers and associated elements in both groups. The lesson was implemented as a sequence of activities in LAMS, including an introduction of the main concepts, an interactive game to reinforce the concepts and assess student understanding and a final branching activity (Figure 2). The general structure of the sequence includes several activities that all students must complete as well as different execution paths that depend on the student’s performance.

The game’s main characters are a couple of turtles called Odd and Even. After a brief introduction, the students must solve different puzzles involving the identification of odd and even items (Figure 3). The level of difficulty of each puzzle increases as the students advance in the game. Interaction is through drag & drop actions. The game has five levels and the expected completion time of the game is 15 minutes.

The educational game includes in-game assessment of student interactions. When a student fails in solving a puzzle (e.g., she/he drops an odd number in the Even chest – Figure 3) a number of points are subtracted from the total score, depending on the difficulty of the puzzle. This information is appended to an assessment report, including a timestamp, the puzzle level and whether it related to odd or even groups, but is not shown to the students. At the end of the game the final score and the assessment report with information about errors, timestamp and type of error are automatically sent back from the game to LAMS, where the educator can access them (Figure 4).
After playing the game, the next step in the LAMS sequence depends on the individual performance of each student. Depending on the game final score, students may carry on with the final activities planned for the lesson or complete an additional reinforcement module. A LAMS Branching Activity controls the flow of the sequence automatically (Figure 5) by providing discriminating branches either for finishing the sequence when the score is higher than 60 points (“Pass” condition in Figure 6) or for visiting the reinforcement section when the score is 60 points or less (“Fail” condition in Figure 6).

![Figure 5. Detail of the branching activity that appears on Figure 2](image)

![Figure 6. Detail of LAMS dialog box to match conditions and branches of the two paths in Figure 5](image)
Results of the case study

Figure 7 shows some of the data extracted. In this figure, STUx_y is a student identifier to maintain their anonymity, where x is the turn and y the number assigned to the student in each turn. As Figure 7.a depicts, 16 out of 26 students (61.5%) completed the first execution of the game with a “pass” score and finished the activity without using the reinforcement material or the second execution of the game. Figure 7.b and 7.c focus on the remaining 10 students. In this group, three students achieved a “pass” score on the second game and one failed this activity again. All these four students who finished the second game achieved better results than in the first game’s execution, even though one of them did not achieve the minimum pass score. The six remaining students were stuck when the session ended and did not complete the activity. One of them remained stuck on the first game, another in the reinforcement presentation and four in the second execution of the game.

![Figure 7](image)

*Figure 7. Charts extracted for the analysis of the data gathered from the LAMS*

Still focusing on the 10 students that required the reinforcement, Figure 7.b depicts the number of errors per student in each game level. Even though the levels were designed with incremental difficulty, students present the highest
the rate of errors in “Level 3” followed by “Level 2” and “Level 4”. Finally, Figure 7.c provides descriptions of the time that each of those students spent in each activity.

Educators involved in the case study were the teacher of the class (T) and the Director of Studies (DS). Two weeks after the session we conducted a one-hour unstructured interview with both educators, following the ideas of Bernsen & Dybkjaer (2009). The interview was recorded and transcribed (the original interview was conducted in Spanish but the excerpts shown in the article have been translated). The aim of this interview was to capture educators’ perceptions about the gaming and integration framework proposed, especially the assessment and adaptation features. A qualitative approach was followed because of the small sample size (only two educators).

In relation to the educators’ opinion on the use of video games in education, the DS pointed out the importance of attractiveness in interactive software as educational tools. She highlighted how previous experiences with ICT had resulted less attractive to students, providing low interactivity and poor engagement through written text. They also pointed out the value of using an interactive and narrative approach to the assessment process, as opposed to a more traditional type of evaluation.

**DS:** We see how the students react negatively to such programs because those contents are unattractive.

**T:** The writing test with a pencil, on paper, without color... this is unattractive to the students, and after two minutes they are exhausted.

Comparing this approach to their usual approach, they showed interest in further using games as evaluation instruments for their subject areas.

We asked the educators about the efforts necessary for the development of sessions of this kind. The educators considered that the task of creating games from scratch was complicated “not only because of the use of technology but also because it is difficult to have an idea for an engaging game that is also attractive”. They identified the possibility of “modifying and adapting a game previously created” as very interesting, but they also highlighted that they “would need prior training to use these tools”.

We asked the educators about the assessment possibilities of <e-Adventure> games and the reports we had gathered using LAMS. They were very interested in this kind of assessment (“This evaluation method is easier for us”), and they highlighted the possibility of extracting more information than in conventional tests.

**DS:** Not only does it reflect the overall result but you can also extract additional information such as time spent in different parts, the difficulty for each student in particular and other aspects that you cannot know through paper and pencil.

**T:** Besides, in a traditional exam you cannot keep an eye on each student and with this approach you can extract more personalized information.

When we asked them about the possibility of changing the sequence flow after taking the information extracted from previous activities into account, the director of studies agreed and asserted:

**DS:** This is a key concept. It is very interesting if we can detect not only what students are doing during the sessions but also what the students’ problems are. Then we can modify the methodology trying to get all students to acquire the important concepts.

The teacher offered to relate some experiences from her class. She pointed out that some students complete all the activities without problems. In this sense the educator found the possibility of adding extra content or more advanced goals interesting, even if that content or goal belonged to another course, so that “this system allows for managing the different learning paces”.

314
Discussion

The main objective of the case study was to gather educators’ perceptions about the benefits, flaws and feasibility of use of the framework. Given the small number of students and teachers involved, it was not intended to evaluate the learning effectiveness of the game-based approach nor the potential of the assessment and flow adaptation capabilities to improve education. For this reason, the case study presents simple assessment and adaptive features to facilitate the understanding of the framework by educators.

The overall results of this experience are positive. Educators found the game to be useful and gave a positive appreciation of the balance between the effort of preparing and executing the sequence of activities (not just the game) and the amount of useful information gathered, how the experience was adapted at runtime, and the level of control they had during the process. Educators highlighted the advantages of the adaptation of the learning experience to different learning paces, promoting individualized learning, and the great amount of information that can be extracted.

In addition, educators perceived that the extraction of the game’s assessment data and its linking with LAMS were easy enough for them, but they also pointed out that they felt that independent game development was out of their reach, even using the tools provided. They did, however, point out that they thought they would be able to adapt existing games to their needs and even use the games as a new assessment tool, as long as they had the resources and adequate training.

Conclusions and future work

In this paper we have proposed a framework trying to facilitate the use of games in learning designs by educators. The framework is built on the ideas of powering educators with assessment and flow-adaptation capabilities, and fosters the reuse of learning designs with games. We also present an application model based on two pre-existing e-learning platforms that implements the frameworks and deals with implementation issues (e.g., game delivery). Finally, we put the application model into practice in a case study with six-year-old students.

Some of the ideas proposed in our framework are present in other approaches or educational tools. For example, the notion of establishing relations among the activities in a course so that they can result in an adaptive learning flow has been around for years. Numerous approaches for conditional branching have come from the field of Adaptive Hypermedia, resulting in a number of educational tools (De Bra, et al. 2003; Weber & Brusilovsky 2001, Brusilovsky, 2004). However, these approaches usually rely excessively on automatic adaptation, limiting educators’ participation during the educational experience. In contrast, our approach focuses on giving educators capabilities to control the flow at all times to increase the educational value.

In the e-learning field there are also several works supporting adaptive learning. On the one hand, there are e-learning standards such as SCORM, which includes basic adaptive sequencing features; and IMS Learning Design (IMS-LD), which can support complex adaptive learning flows due its flexibility that allows educators to define virtual courses following any pedagogical approach (Van Es & Koper, 2006). However, the sequencing in SCORM turns out to be insufficient for highly interactive contents (Shute & Spector, 2008), there are few systems that fully implement IMS-LD, and the effective use of the supporting IMS-LD editors still requires significant knowledge about the specification. These aspects limit the possibility of reusing content and learning designs.

The application model proposed in this work, based on extensions of the previously existing LAMS and e-Adventure platforms provides a more accessible solution, highlighting the role of the educator and providing support for the desirable characteristics proposed within the framework. Our case study has been useful in determining whether educators without extensive ICT training can find the implementation of this technology beneficial, although its small size does not allow us to fully validate our approach. This will require carrying out additional studies with lessons that present more complex assessment and adaptation features and larger sample sizes, as well as an in-depth examination of how our approach compares with other approaches for game integration.
The evaluation of reusing pedagogically sound designs including games is planned for a later stage. To validate this aspect, a community of users needs to be established first, and a wide range of learning designs with games should be available. Both goals cannot be reached in the short-term. We have already initiated some initiatives for this purpose: the LAMS official release that includes support for <e-Adventure> activities (v2.3.5) has been recently made available for public use. We are also promoting different repositories. As proposed by the workflow, the LAMS sequence and the parity game along with more sequences and games have been included both in LAMS community and <e-Adventure> repositories. The perceived acceptance of these materials within LAMS and <e-Adventure> users may allow us to estimate whether there is a real interest in reusing this kind of content, and therefore the practical applicability of the approach.

There are also other open issues which need further research. One is related to testing the applicability of the framework implementing the course following e-learning standards as IMS LD or SCORM, comparing the benefits and pitfalls against this specific application model. In addition, our current work focuses on gathering adaptation data from a technical perspective, rather than indicating what to do with it. Finding effective ways to use the data extracted from the game for adaptation purposes is still an open research question. However, we expect the notion of promoting the reuse of contents and lesson patterns supported by the application mode to facilitate this process. We are currently working on improving the customisation possibilities introduced by this model, including providing both extra materials for advanced students and remedial contents for those whose do not achieve the learning objectives. We are also working on the proposal and development of different sample courses and lessons to include them in publicly available repositories.

Acknowledgements

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References


A Cognitive Apprenticeship Approach to Facilitating Web-based Collaborative Problem Solving

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ABSTRACT

Enhancing students’ problem-solving abilities has been recognized as an important and challenging issue for technology-enhanced learning. Thus, previous research has attempted to address this issue by developing various mechanisms, among which a cognitive apprenticeship model can particularly enhance students’ abilities. However, it is not clear whether such a mechanism is suitable for every learner. Thus, this study examines the effects of human factors on problem-solving effectiveness in the cognitive apprenticeship model. Among various human factors, this study focuses on cognitive styles, with an emphasis on Witken’s Field Dependence. The results indicate that Field Dependent learners can get great benefits from the cognitive apprenticeship model via collaborative learning. Implications for how to accommodate the needs of different cognitive style groups are discussed.

Keywords

Problem-solving ability, collaborative learning, cognitive apprenticeship, cognitive styles, inquiry-based learning

Introduction

With the rapid spread and advancement of information technology, schooling not only plays an important role in imparting knowledge to students, but also in cultivating their abilities of collecting data, extracting information from the data, and applying the collected information to deal with upcoming challenges and problems (Ates & Cataloglu, 2007; Dogru, 2008; Francis, 2008; Pimta et al., 2009; Saskia & Gerjets, 2008; Zakaria & Yusoff, 2009). Consequently, fostering students’ problem-solving abilities has become an important and challenging issue (Chiou, Hwang, & Tseng, 2009). Previous studies have revealed several factors that affect students’ problem-solving abilities, such as the students’ level of intelligence and the socioeconomic background of their parents, the quality of the learning materials, the learning methods, and the adopted instructional strategies for problem-solving (Mustafa & Özgül, 2009; Oloruntegbe, Ikpe, & Kukuru, 2010; Zheng, 2007).

Among these factors, learning methods and problem-solving instruction strategies are considered as being key factors that determine students’ problem-solving abilities (Harskamp & Suhre, 2007; Lo, 2009; Tsai & Shen, 2009). Researchers have reported that information searching skills and problem-solving abilities are highly correlated (Eisenberg & Berkowitz, 1990). Bilal (2001, 2002) further indicated that the lack of effective information searching strategies and high-order thinking abilities could influence students’ performance in searching for information on the Internet; moreover, it would be difficult for students to enhance their high-order thinking ability by only observing and imitating the cognitive skills of teachers in a traditional learning context. In other words, a more effective learning approach is needed for helping the students to acquire both cognitive and metacognitive skills. Cognitive apprenticeship is such a learning model which has been reported to be effective in promoting students’ high-order thinking, cognitive skills and oral presentation abilities (Ertl, Fischer, & Mandl, 2006; Hwang, Yang, Tsai, & Yang, 2009; Schellens & Valcke, 2006).

In this study, a cognitive apprenticeship approach for conducting inquiry-based collaborative learning activities is proposed. With this approach, the students are given the cognitive apprenticeship strategy, and complete learning tasks collaboratively. An experiment has been conducted to evaluate the effectiveness of this approach. More specifically, the test scores of the students using this approach are compared with those of a group of students who learned with the cognitive apprenticeship strategy individually and another group who learned with the traditional form of instruction. In addition, to investigate the effects of our approach in depth, the cognitive styles of the students are taken into account when analyzing their learning performance.
Literature Review

Cognitive apprenticeship was proposed by Brown, Collins and Duguis (1989). It provides an opportunity for novices to observe how instructors or experts solve complex problems in an authentic context via the following steps: (a) Modeling: the experts demonstrate and explain their way of thinking for students to observe and understand; (b) Coaching: the students practice the methods, while the experts advise and correct; (c) Scaffolding: through increasing the complexity of problems and decreasing the level of assistance according to the students’ progress, the experts progressively help the students successively approximate the objective of accomplishing a task independently; (d) Articulation: the students are given opportunities to articulate and clarify their own way of thinking; (e) Reflection: the students compare their own thoughts with those of experts and peers; (g) Exploration: the students manipulate and explore the learned skills or knowledge to promote their true understanding.

Researchers have reported that the cognitive apprenticeship model can strengthen students’ high-order thinking abilities. For example, Snyder (2000) found that the cognitive apprenticeship group students showed significantly better problem-solving performance than the text-based group students. Hendricks (2001) and Stockhausen and Zimitat (2002) found that the cognitive apprenticeship model was helpful to elementary school students in promoting their cognitive skills and causal reasoning ability in a science course. Liu (2005) revealed that the course based on the web-based cognitive apprenticeship model improved pre-service teachers’ performance and attitudes towards instructional planning more effectively than did the traditional training course. Hwang et al. (2009) further indicated that the cognitive apprenticeship model was helpful to graduate students in promoting their learning efficiency and effectiveness in performing complex science experiments. These findings provide evidence that the cognitive apprenticeship approach is able to effectively improve the high-order thinking ability of students.

On the other hand, several previous studies have also indicated the problems of conducting such a complex instructional activity. One of the key problems is due to the difficulty of providing one-to-one cognitive apprenticeship-based learning. Usually a teacher needs to face several students at the same time; therefore, it is difficult for teachers to coach individuals by taking the learning status of each student into account in the current educational setting, in particular, for complex cognitive development (Dickey, 2007; Spector, 2010). Under such circumstances, middle- and low-achieving students are unlikely to experience in-depth cognitive development without sufficient supports from their teachers or peers; consequently, careful learning design and support are needed, such that the students will not feel helpless and depressed, or even lose their willingness to learn (Hwang & Chang, 2011; Shih, Chuang & Hwang, 2010). That is, the lead-in of effective learning strategies has become an important issue for conducting problem-solving activities.

Among various learning strategies, collaborative learning has been recognized as being a highly potential way of assisting students in dealing with complex problems (Chu, Hwang, Tsai, & Chen, 2009). According to social development theory, students can improve their cognitive skills via collaborative interactions with more competent partners (Vygotsky, 1978). Moreover, numerous positive results have demonstrated the importance of collaborative learning. For example, Barron (2000) indicated that the peer collaboration model could be embedded in instructional design to facilitate high graders’ problem-solving abilities in math. Li (2002) reported the effectiveness of group work in promoting students’ critical thinking skills, problem solving skills, social skills and self-esteem. Researchers have indicated that collaborative learning often leads to better learning outcomes than individual work (Lipponen, Hakkarainen, & Paavola, 2004; Neo, 2003). Furthermore, Mercier and Frederiksen (2008), Lazakidou and Retalis (2010), and Kim and Hannafin (2011) all found that students’ problem-solving abilities could be significantly enhanced by using computer supported collaborative learning strategies. However, researchers have also pointed out that positive benefits do not automatically happen in a collaborative learning environment unless a sound instructional design is provided (Hwang, Chu, Lin, & Tsai, 2011; Lazakidou & Retalis, 2010; Schellens & Valcke, 2006). Consequently, it has become an important and challenging issue to propose a cognitive apprenticeship model that takes peer collaboration into account to help students deal with those complex problems during the learning activities.

Collaborative learning involves students working together in small groups towards a common goal, and these students may have different characteristics, skills and preferences. In other words, individual differences play an important role. Among various individual differences, past research has indicated that cognitive style has a significant effect on learners’ information seeking because it influences the way individuals collect, analyze, evaluate, and interpret information (Harrison & Rainer, 1992). Cognitive styles refer to how individuals prefer to
organize and represent information (Riding & Rayner, 1998). There are many dimensions of cognitive styles, such as Visualized versus Verbalized, Right-Brained versus Left-Brained, Global-Holistic versus Focused-Detailed, or Field-Dependent versus Field-Independent. Among these dimensions, Field Dependence is widely examined in the studies of information seeking (e.g., Clewley, Chen, & Liu, 2011) because it reflects how well a user is able to restructure information based on the use of salient cues and field arrangements (Weller, Repman, & Rooze, 1994).

Field Dependence refers to the degree to which a user’s perception or comprehension of information is influenced by the surrounding perceptual or contextual field (Jonassen & Grabowski, 1993). The key issue of Field Dependence lies within the differences between Field Dependent and Field Independent learners, which are presented in Table 1.

<table>
<thead>
<tr>
<th>Field Dependent Learners</th>
<th>Field Independent Learners</th>
</tr>
</thead>
<tbody>
<tr>
<td>They are externally directed and are easily influenced by salient features.</td>
<td>They are internally directed and process information with their own structure.</td>
</tr>
<tr>
<td>They experience surroundings in a relatively global fashion and struggle with individual elements.</td>
<td>They experience surroundings analytically and are good with problems that require taking elements out of their whole context.</td>
</tr>
<tr>
<td>They are more likely to accept ideas as presented.</td>
<td>They are more likely to accept ideas only strengthened through analysis.</td>
</tr>
</tbody>
</table>

As shown in this table, Field Independent and Field Dependent learners have different characteristics. Thus, this study compares the learning performance of Field Dependent and Field Independent learners within the cognitive apprenticeship model.

**Method**

**Participants**

Eighty-eight fifth-grade students (11-12 year olds) participated in this study. All of them were taught by the same teacher who had had five years’ experience of teaching social science courses. The students were randomly assigned to three groups: one experimental group and two control groups. The experimental group adopted the combination of collaborative learning and cognitive apprenticeship strategy, while control group one adopted the combination of personal learning and the cognitive apprenticeship strategy and control group two merely accepted the combination of personal learning and direct instruction strategies.

**Learning environment**

A web-based searching behavior analyzing system, Meta-Analyzer (Hwang, Tsai, Tsai & Tseng, 2008), was employed to assist the teachers in tracing and analyzing the students’ information-searching behaviors for specific
questions. Meta-Analyzer has been recognized as being an efficient tool for conducting and analyzing web-based problem-solving activities (Hwang & Kuo, 2011; Tsai, Tsai and Hwang, 2011). This system employs metasearch engine technology (Tseng, Hwang, Tsai and Tsai, 2009). A metasearch engine is a system that provides access to existing search engines. When it receives a query, it can efficiently invoke the available search engines, collect and reorganize the results returned from the search engines, and present the data to the user after reformatting them in an appropriate way, as shown in Figure 1.

As shown in Figure 2, the student interface consists of three operation areas: the question and answer area is located on the left side of the browser, the information-searching area is located on the upper-right side, and the web pages found by the search engines are given on the lower-right side. To answer the question, the student can input keywords to search for information, and then browse the web pages that might be relevant to the topic.

Figure 2. Introduction to the Meta-Analyzer Interface

Recording the student information searching portfolio

Figure 3. Student online information-searching behaviors recorded in the database
The entire user’s searching portfolio, including the keywords, the browsed pages, the time spent browsing web pages and the user behaviors on the web etc., are recorded in full in the server for further analysis, as shown in Figure 3.

**Experiment design**

In this study, the Learning Together (LT) model of collaborative learning is employed according to the requirements of the learning activity. The LT developed by David and Roger Johanson engages students working in four- or five-member heterogeneous groups on assignment sheets. Each group is required to complete tasks and hand in a single sheet, and they then receive praise and rewards based on the group product (Johnson et al., 1991).

During the learning activity, the students in both the experimental group and control group one were guided to learn with the cognitive apprenticeship approach based on the modeling, coaching, scaffolding, articulation, reflection, and exploration phases proposed by Collins, Brown, and Newman (1989). On the other hand, the learning activity for control group two was conducted with a traditional instruction approach; that is, the teacher presented the learning materials, assigned learning tasks, and gave feedback to the students. Moreover, Meta-Analyzer was employed as a constructive tool for analyzing the problem-solving abilities of each group.

The major difference between the experimental group and control group one is the intervention of the collaborative learning model incorporated in the experimental group. Moreover, the LT model was embedded in the learning procedure of the experimental group. Before conducting the learning approach, the students in the experimental group were divided into 3-member learning groups with a heterogeneous grouping approach; that is, each learning group consisted of a high-achieving, a middle-achieving and a low-achieving student. The students in each learning group were asked to solve the questions collaboratively. During the problem-solving activities, the high-achieving students played an important role in helping their group members understand the problem-solving procedure. To encourage the high-achieving students to help their peers, the learning group which obtained the highest score was given praise and rewards. In the meantime, those middle- and low-achieving students were able to observe and learn what the high-achieving students had done during the collaborative learning activity. Such a collaborative strategy is based on the concept of zone of proximal development (ZPD) proposed by Vygotsky (1978) in the theory of social constructivism.

In this study, seven sets of constructive questions concerning different social issues for problem solving were designed and arranged in the experiment (see Appendix 1). Prior to the experiment, all of the students were given a demonstration and a chance to practice using the Meta-Analyzer system, as well as an explanation of how experts think during the problem-solving process. Each set of questions representing a social issue was introduced to increase their prior knowledge. Subsequently, the first set of questions shown on Meta-Analyzer was given to the students as a pre-test. Afterwards, the experimental group and control group one, both of which adopted the cognitive apprenticeship model, started with the following four phases:

**Phase one: modeling, coaching, scaffolding**

The teacher demonstrates how to solve problems by adopting appropriate keywords, selecting relevant web pages, integrating information with related pages, and answering questions carefully based on the problem-solving procedure. Accordingly, students are required to do the 2nd and 3rd set of questions by themselves during two consecutive weeks and the teacher is responsible for coaching and scaffolding them at any time. After each question is completed, the teacher articulates how the question should actually be solved in detail until the students deeply understand the question.

**Phase two: coaching, scaffolding, articulation and reflection**

The teacher does not demonstrate how to solve problems, but students are asked to articulate their knowledge, and share how they carried out the problem-solving processes with others. In this way, students are able to compare their own problem-solving processes with those of peers or teachers. Finally, the teacher comments on the students’
presentation as a conclusion. Similarly, the students need to complete the other two sets of questions (4th and 5th) in two consecutive weeks.

**Phase three: articulation and reflection**

The learning activity mainly focuses on student-centered learning without any coaching or scaffolding from the teacher. Once students complete answering the 6th set of questions, the teacher picks some of them to articulate their knowledge, and share how they carried out the problem-solving processes with others. Likewise, the students are able to compare their own problem-solving processes with those of their peers or teacher. Finally, the teacher also comments on the students’ presentation as a conclusion.

**Phase four: exploration**

Students are asked to explore the 7th set of questions autonomously, which is also viewed as a post-test. After the questions are completed, the students are required to fill out questionnaires and conduct an assessment of their problem-solving ability.

**Figure 4.** Experimental flowchart for each group

**Measuring tools**

The assessment of problem-solving ability in the study originated from Speedie et al. (1973). The assessment was designed for measuring the problem solving of elementary high-grade students and uses both pictures and literary composition. It consists of five aspects, including “being aware of the existence of the problem”, “confirming the nature of the problem”, “identifying factors related to the problem”, “identifying necessary information related to the problem”, and “deciding on a solution.” The inter-rater reliability for the assessment in the study was examined by two senior social science teachers by evaluating 50 examinees (non-subjects). Based on Pearson correlation analysis
of the relationship between the two raters, the correlation coefficient reveals significant correlation (r=0.91), implying that the assessment of problem-solving ability in the study has high inter-rater reliability.

To measure the cognitive styles of the students, the Group Embedded Figures Test (GEFT) developed by Witkin, Moore, Goodenough and Cox (1977) was adopted. This is due to the fact that the GEFT has been widely used in the studies of learning technology in the past decades (Abouserie & Moss, 1992; Altun & Cakan, 2006; Shahsavar & Hoon, 2011). The test was designed with 25 simple and complex figures for measuring the field independency of children over 10 years of age, which is consistent with the subjects of this study. It consists of three mini tests with time limitations of 2, 5, and 5 minutes, respectively. The score is computed based on the number of correct answers in the 2nd and 3rd mini tests with complex figures in the study because the 1st mini test with simple figures is designed for orientation only. The higher the score is, the higher the field independency is. The selection of Field Independent students was calculated as those with over the mean score plus half the standard deviation. In contrast, those whose score was under the mean score plus half the standard deviation were identified as Field Dependent students (Kelly, 1939); the rest were neglected because of not being included in the scope of the research questions.

In designing the seven sets of constructive questions, two senior social science teachers and one university professor worked together to organize the questions based on the social issues and problem solving theory. Accordingly, these questions show good face validity. Besides, as for inter-rater reliability, the teachers evaluated 12 non-experimental group students before conducting the experiment to ensure the consistency of the score standard. By Pearson correlation analysis of the two raters, the statistical results show that the correlation coefficient (r) of the first three subquestions (knowledge-finding questions) reached 0.92 (p<.001), while the correlation coefficient of the last subquestion (the argument question) reached 0.77 (p<.01), implying that the assessment of online problem-solving ability with Meta-Analyzer has high inter-rater reliability in this study.

Results

Effect on the problem-solving abilities of FD and FI students

The study attempts to investigate the difference in the problem-solving abilities of Field Independent (FI) and Field Dependent (FD) students conducted in one experimental and two control groups. Table 2 presents an overview of the mean post-test scores and the standard deviations of the FI students in different research conditions analyzed by analysis of variance (ANOVA). It shows no significant difference among the three groups when it comes to the aspect of field independency. However, Table 3 shows significant difference among the three groups in terms of the aspect of field dependency. Post hoc analysis with the Tukey HSD method was used and indicated a significant difference between the experimental group and control group one, and control group two (F=22.36, p<.001), implying that the FD students with the collaborative learning strategy exhibited better performance than those without the same strategy.

<table>
<thead>
<tr>
<th>Styles</th>
<th>Groups</th>
<th>N</th>
<th>Mean</th>
<th>S.D.</th>
<th>F</th>
<th>Post Hoc test (Tukey HSD method)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Field Independence</td>
<td>(1) Experimental group</td>
<td>7</td>
<td>15.14</td>
<td>2.27</td>
<td>.32</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(2) Control group one</td>
<td>4</td>
<td>15.25</td>
<td>3.60</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(3) Control group two</td>
<td>10</td>
<td>14.30</td>
<td>2.26</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Styles</th>
<th>Groups</th>
<th>N</th>
<th>Mean</th>
<th>S.D.</th>
<th>F</th>
<th>Post Hoc test (Tukey HSD method)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Field Dependence</td>
<td>(1) Experimental group</td>
<td>11</td>
<td>16.27</td>
<td>1.85</td>
<td>22.36***</td>
<td>(1)&gt;(2)</td>
</tr>
<tr>
<td></td>
<td>(2) Control group one</td>
<td>12</td>
<td>12.58</td>
<td>1.62</td>
<td></td>
<td>(1)&gt;(3)</td>
</tr>
<tr>
<td></td>
<td>(3) Control group two</td>
<td>12</td>
<td>11.08</td>
<td>2.19</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

***p<.001
Interaction effect between cognitive styles and instruction strategy facets

Another statistical analysis to investigate the impact of the integration of the cognitive apprenticeship model and the collaborative learning strategy is to examine the interaction effect between cognitive styles and instruction strategies by using two-way ANOVA. In other words, we attempted to investigate the effect of cognitive styles on students’ learning performance with or without the intervention of the collaboration learning strategy. Two-way Analysis of Variance (Two-way ANOVA) was employed to analyze the interaction effect between the two independent variables. The initial finding showed significant difference between the two independent variables (F=5.31, p=0.008<.01), implying that there was a significant interaction effect between cognitive styles and instruction strategies. Thus, it is necessary to further analyze the differences in the students’ learning performance in each facet. In terms of cognitive styles, one-way ANOVA was used to analyze the learning performance of the students in the experimental group and in control group one. The result shows that there was no significant difference between the two different strategies in terms of field independency (F=0.05, p=.83>.05). On the contrary, there was significant difference between the two groups for the aspect of field dependency (F=26.00, p<.001). Effect size (η² =0.55) was also examined and showed a significant effect (Cohen, 1992). Thus, it can be seen that the FD students in the experimental group had significantly better performance than those in control group one. In other words, FD students are able to achieve better learning performance when the collaborative learning strategy is embedded in the instructional design.

Similarly, one-way ANOVA was employed to analyze the students’ learning performance in terms of instruction strategies. The result shows that there was no significant difference (F=1.70, p=.203>.05) between the FI and FD students in the experimental group, as shown in Table 4. On the contrary, there was significant difference between the two groups as to the aspect of field dependency (F=3.90, p=.033<.05), as shown in Table 5. Effect size (η² =0.23>0.14) was also examined and showed a significant effect. Thus, it can be seen that there was no significant difference between the FI and FD students in the experimental group, while significant difference existed between the FI and FD students in control group one. This implies that FD students are able to enhance their learning performance via the collaborative learning strategy while FI students are not. This is probably because the former rely more on external frames of reference and operate best where analyses are already provided (Lyons-Lawrence, 1994), while the latter use an internal frame of reference to organize information (Reiff, 1996).

<p>| Table 4. Summary of analysis of simple main effect on the learning performance of the experimental group |</p>
<table>
<thead>
<tr>
<th>Groups</th>
<th>Cognitive styles</th>
<th>N</th>
<th>Mean</th>
<th>S.D.</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(1) Field Independence</td>
<td>7</td>
<td>15.14</td>
<td>2.27</td>
<td>1.70</td>
</tr>
<tr>
<td></td>
<td>(2) Field Dependence</td>
<td>11</td>
<td>16.27</td>
<td>1.85</td>
<td></td>
</tr>
</tbody>
</table>

<p>| Table 5. Summary of analysis of simple main effect on the learning performance of control group one |</p>
<table>
<thead>
<tr>
<th>Groups</th>
<th>Cognitive styles</th>
<th>N</th>
<th>Mean</th>
<th>S.D.</th>
<th>F</th>
<th>η²</th>
<th>Post hoc test (Games-Howell method)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(1) Field Independence</td>
<td>4</td>
<td>15.25</td>
<td>3.59</td>
<td>3.90*</td>
<td>0.23</td>
<td>(1)&gt;(2)</td>
</tr>
<tr>
<td></td>
<td>(2) Field Dependence</td>
<td>12</td>
<td>12.58</td>
<td>1.62</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Similar results have been proved, and imply that FD students are equipped with a preference for social learning in their personal traits; in contrast, FI students prefer learning by themselves. For this reason, it can be found that the FD students in the experiment were able to obtain better achievement than those in control group one. On the contrary, the FI students performed significantly better than the FD students in control group one without the intervention of the collaborative learning mechanism.

Discussion

This study provides valuable findings related to the web-based problem-solving performance of FD and FI students. A significant difference was found between the groups with or without collaborative learning intervention in terms of Field Dependent students. Additionally, there was significant difference between the FI and FD students in the group without the collaborative learning mechanism, which is consistent with previous research (Howard, 1993). That is, FD students have a tendency to undertake global and passive learning strategies, since they are influenced by format-
structure and need salient cues in learning (Chen & Macredie, 2004; Chou, 2001). Conversely, FI students rely more on internal references and are less affected by format-structure in learning. That is, FI students prefer to employ analytical and active learning approaches (Chou, 2001). Previous investigations (Ford, 1995; Fullerton, 2000) in cognitive styles have also indicated that learning is significantly better in matched than in mismatched conditions. Ford and Chen (2001) conducted an empirical study on the effect of matching and mismatching on students’ learning performance, and found that students in conditions that matched their cognitive styles obtained higher test scores than did those in conditions that were mismatched.

According to the findings of previous studies, students’ learning performance could be determined by matched or mismatched conditions based on their cognitive styles (Germanakos, Tsianos, Lekkas, Mourlas, Belk, & Samaras, 2007; Inan, 2010; Pask, 1976). Thus, it can be seen from the research results that FD students are suitable for the cognitive apprenticeship model with collaborative learning strategy, while FI students prefer the cognitive apprenticeship model without the collaborative learning strategy.

Conclusions and implications

In this study, a cognitive apprenticeship approach is proposed for conducting collaborative problem-solving learning activities on the Internet. To investigate the effect of the proposed model, an empirical study has been performed with 88 participants distributed in three groups with different strategies, and a survey has been administered to the students following the tests. Moreover, the cognitive styles of the students are taken into consideration for analyzing their learning performance in depth.

The experimental results via one-way and two-way ANOVA analyses show that the integration of cognitive apprenticeship and collaborative learning strategies brings FD students significantly better problem-solving performance than those in the other two control groups, further demonstrating the personal traits of Field Dependent students. Additionally, the result also reveals that the FI students demonstrated better problem-solving ability than did the FD students in control group one with personal effort, which is consistent with the personal trait of Field Independent learners. In other words, the FD students in the experimental group were given chances to inspect what the FI students did during the problem-solving process so that they felt more confident in articulating to peers than the students in control group one. These findings are consistent with those reported by previous studies (Ertl, Fischer, & Mandl, 2006; Hwang, Yang, Tsai, & Yang, 2009), indicating that the integration of the cognitive apprenticeship model and collaborative learning theory could promote FD students’ high-order thinking, cognitive skills and oral presentation abilities. Accordingly, this study concludes that the integration of cognitive apprenticeship and collaborative learning mechanisms within online inquiry-based learning environments has great potential in promoting FD students’ problem-solving abilities and learning attitude toward social science through the assistance of FI students. Thus, teachers are able to pay more attention to help those who need assistance.

Although the focus of the study has been on cognitive styles, it should be noted that other human factors may affect learners’ interaction with the Internet, including affective factors, gender differences and age differences. Therefore, an important direction for future work is the investigation of these factors and identification of the major design features which interact with each other. Another important issue related to this study is the strategy of promoting students’ information-searching competence, including keyword-adopting and information-abstracting skills. Researchers have suggested conducting those training programs before the learning activity (Hwang et al., 2008); therefore, it is worth investigating the effect of various strategies of training for information-searching competence in future studies, in particular, the instructional strategies that can be incorporated into the cognitive apprenticeship approach. Furthermore, how to cultivate and encourage students to engage their prior knowledge with a particular topic and make their thinking visible in the process of learning is also an important issue (Bell, 1998; Dickey, 2007). Consequently, we are trying to investigate the effect of using some computerized Mindtools (Jonassen, 2000), such as concept maps, in some web-based problem-solving activities.

Acknowledgements

This study is supported in part by the National Science Council of the Republic of China under contract numbers NSC 99-2511-S-011-011-MY3, NSC 99-2631-S-011-002, and 99-2511-S-008 -003 -MY2.
References


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## Appendix 1

### Seven sets of constructive questions for problem-solving ability

<table>
<thead>
<tr>
<th>Set No.</th>
<th>Topics</th>
<th>1&lt;sup&gt;st&lt;/sup&gt; question</th>
<th>2&lt;sup&gt;nd&lt;/sup&gt; question</th>
<th>3&lt;sup&gt;rd&lt;/sup&gt; question</th>
<th>4&lt;sup&gt;th&lt;/sup&gt; question</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Credit Card Slave</td>
<td>How many credit card slaves are there in Taiwan?</td>
<td>What leads them to become credit card slaves?</td>
<td>What disadvantages and advantages are there when shopping with a credit card?</td>
<td>If you had a credit card, how would you use it to avoid becoming a credit card slave?</td>
</tr>
<tr>
<td>2</td>
<td>Renewable energy</td>
<td>What are the three forms of power generation used in Taiwan?</td>
<td>In addition to the previous methods, what other methods are there? Give a short introduction to each.</td>
<td>What are the disadvantages and advantages of nuclear power and thermal power?</td>
<td>If you were the Minister of Energy, what form of power generation would you adopt, and why?</td>
</tr>
<tr>
<td>3</td>
<td>Greenhouse effect</td>
<td>What countries are the world’s top two carbon dioxide emitters?</td>
<td>What are the impacts on the Earth of the emission of lots of carbon dioxide?</td>
<td>What solutions can decrease carbon dioxide emissions in life? What can you do?</td>
<td>If you were the Minister of Environmental Protection, what would you do to lower carbon dioxide emissions?</td>
</tr>
<tr>
<td>4</td>
<td>Garbage problem</td>
<td>What are the impacts on the Earth if lots of rubbish is produced? E.g. water, air, soil etc.</td>
<td>What are three main methods of waste disposal? How do they work?</td>
<td>What are the differences among &quot;landfill&quot;, &quot;garbage incineration&quot;, and &quot;recycling&quot;?</td>
<td>What waste disposal method would you accept to decrease the garbage problem?</td>
</tr>
<tr>
<td>5</td>
<td>Water shortage</td>
<td>How many liters of water are used on average per day in Taiwan?</td>
<td>The annual rainfall exceeds 2,500mm in Taiwan, but there is still a water shortage, why?</td>
<td>Do you think the construction of reservoirs can solve water shortages in Southern Taiwan? What impact would they have?</td>
<td>What specific actions can you take to help conserve water at school, at home or anywhere else?</td>
</tr>
<tr>
<td>6</td>
<td>Falling birthrate problem</td>
<td>Please find out the birthrate in 1979 and 2009 in Taiwan, respectively.</td>
<td>Currently, what is leading to the falling birthrate problem in Taiwan?</td>
<td>What industries can be affected by the low birthrate problem?</td>
<td>If you were the President or Premier, what policy would you advocate to promote the birthrate?</td>
</tr>
<tr>
<td>7</td>
<td>Ageing problem</td>
<td>Please find out the population over 65 years old in 1979 and 2009 in Taiwan, respectively.</td>
<td>There will be an ageing society in Taiwan. What are the potential problems then?</td>
<td>What factors lead to an ageing society?</td>
<td>If you were the Minister of the Interior, what steps would you take to solve the ageing problem?</td>
</tr>
</tbody>
</table>
An Exploratory Study of the Cultural Habits Change Process Triggered by the Use of IT: A Faculty Student Knowledge-Sharing Platform Case Study

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ABSTRACT
In this research, we explore the impact on teachers of implementation of the Faculty Student Knowledge-Sharing Platform (FSKSP) in their college. Specifically, we focus on the effect on those teachers of the need to share publicly their knowledge and teaching material as the result of FSKSP implementation. In addition, we report the experience and progress they acquire when choosing to change their traditional, habitual teaching and sharing modes. The case study focuses on a college of technology well-renowned among universities in Taiwan for its fully integrated electronization of teaching. The study shows that delivery of knowledge to and sharing of knowledge with students through the FSKSP differs enormously from the long-established verbal knowledge sharing in classroom lectures. In choosing to use the FSKSP and making changes to the interaction between faculty and students, teachers go through the following stages: protection of professional dignity and expertise; panic about whether or not to make changes; compromise in response to information technology trends, and hesitation about whether to continue or to turn back. The research findings provide a good reference for college administrators advocating the introduction of information technology to construct the FSKSP. The findings also assist FSKSP system designers in gaining the necessary understanding of possible conflicts between system features and cultural habits when working to enhance system feature design.

Keywords
Cultural Habits, Knowledge-sharing Platform, Narrative Interview, Phenomenological Research Method

Instruction
In this era of knowledge economy, one of the most important information strategies launched by the Taiwanese government has been to increase national competitiveness through knowledge creation and distribution with the aid of information technology (IT). As store-houses of knowledge, many colleges promote e-learning, constructing faculty student knowledge-sharing platforms (FSKSP), no longer confining teaching to classrooms and blackboards, and knowledge delivery and learning to the limits of time and space. From the socio-technical perspective (Bostrom and Heinen, 1977a, 1977b; Land, 2000), the FSKSP is comprised of technical and social subsystems. Technically, the FSKSP provides technical features such as online sharing of teaching resources, public discussion area for knowledge inquiries and problem solving, and acts as the repository of teachers’ personal teaching resources. The social subsystem consists of cultural beliefs, attitudes, and skills that teachers and students bring to the teaching and learning environments. From the socio-technical perspective, the benefits of FSKSP implementation are derived from the fit achieved through a design process aimed at joint optimization of the technical and social subsystems. However, the major changes in teaching design challenges teachers’ cultural habits, making rather complicated issues such as the planning, implementing and promoting of FSKSP.

In this research, we observe the use of FSKSP in a college of technology well-renowned among colleges and universities in Taiwan for its fully integrated electronization. Despite support for the platform from an administrative perspective, there is evidence of less support for it from teachers in terms of using it for the purpose of knowledge delivery and sharing. Peoples’ habits are molded by the particular culture in which they live, which represents the greatest challenge when technical and social subsystems are integrated (McDermott 1999; Michailova and Husted 2003; Detert and Edmondson 2007). We approach this phenomenon by asking the following question: “How does FSKSP implementation challenge teachers to change their cultural habits with respect to their teaching methods?”

The notion of habit has been introduced into information systems (IS) usage research. For example, Limayem and Hirt (2003) and Jasperson et al. (2005) suggest that habitual (automatic) use, which occurs spontaneously outside of conscious awareness, represents alternative forms of IS use. In line with these studies, the aim of researchers is to resolve questions of what is and what will be (Gregor, 2006). They ask “beyond people’s conscious (intentional) behavior, what factors can explain and predict IS usage?” Their research findings indicate that by including the habit construct in a behavior model such as Ajzen’s (1985) theory of planned behavior (TPB), habit has explanatory power.
for predicting an individual’s information systems behavior (e.g. Limayem and Hirt 2003; Kim and Malhotra 2005; Limayem et al. 2007). In this stream of research, the term habits refers to the non-intentional (automatic) enactment tendencies developed through the history of the individual, where particular stimuli trigger specific behaviors even when the individual does not instruct himself/herself to behave in such a way (Thorngate 1976; Triandis 1977, 1980). Thus, habit in terms of IS usage refers to the non-deliberate, automatically-inculcated response that individuals may bring to IS usage (Limayem and Hirt 2003).

The aforementioned researchers have contributed insights to the study of IS usage behaviors. However, if we assume that habit is a culturally-fixed mode that drives an individual’s social practices both in a group and in a particular context (Weber 1922), then the question of how, why, and when people’s habits challenge their IS usage behaviors remains unanswered. As Verplanken and Aarts (1999) propose, cultural habit is mind-set that improves the perceptual readiness for habit-related cues, preventing an individual from being distracted and from adopting other, less efficient courses of action. Moreover, cultural habit has become fixed through the activities conducted by group members under a specific network over a long period of time. It is an artificial object in life. Durkheim (1911) points out that once habits are endowed with power, they become the rules of conduct, and consequently, may become the greatest obstacles to progress. Take, for example, old-fashioned corporal punishment, constantly present under the influence of the power of habit. Weber (1922) asserts that uniform behaviors of a group are rooted in habits, and habits are the tendency to allow actions that are unreflective and subjective to turn into long-term behaviors.

Habit, Cultural Habit, and Knowledge Distribution in the University Domain

Habit (Automatic behavior)

In this decade, the notion of habit has focused the attention of many IS researchers on the study of information systems (IS) usage. Some of these researchers include Limayem and Hirt (2003), Kim and Malhotra (2005), and Limayem et al. (2007). For example, Limayem and Hirt (2003) indicate that previous IS usage studies have contributed to our understanding of many antecedent factors such as involvement, perceived ease of use, perceived usefulness, and their relationship to intention. They argue that IS researchers also need to focus on factors “that are internal to the individual, yet differ from the rational, deliberate, cognitive decision making the IS academy has pursued thus far.” (p. 66). They introduce the notion of habit, which refers to the non-deliberate, automatically-inculcated response that individuals may bring to IS usage into a behavioral model integrating theoretical constructs of TPB and a relevant subset of Triandis’ (1980) behavioral framework. The research findings highlight the importance of considering both conscious (intentions) and subconscious (habits) factors in explaining usage behavior.

Moreover, Kim and Malhotra (2005) compare two contrasting views in the literature on the nature of the automatic use (habit) perspective and the instant activation perspective. They show that “according to the habit perspective, automatic use occurs because of the force of habit without the formation of intention; thus, past use is believed to weaken evaluation-intention-usage relationship. In contrast, the instant activation perspective posits that automatic
use is simply an expedited form of conscious use; accordingly, as with conscious use, automatic use is still a function of intention, so past use will not weaken the evaluation-intention-usage relationship.” (p.418). The findings show that the evaluation-intention-usage relationship is generally weaker among heavier users than among lighter users.

Furthermore, Limayem et al.’s (2007) research explores the role of habit and its antecedents (such as satisfaction, frequency of prior behavior, stability of context, and usage comprehensiveness) in the context of continued IS usage. In addition, they build and test a theoretical model that integrates the habit construct along with its antecedents into recent work on IS continuance. Habit is proposed to exert a moderator (suppressor) effect on the relationship between intention and continued IS usage behavior. Modeling habit this way means that the stronger the habit, the lower the prognostic power of intention on the actual behavior.

In this line of research, habit refers to the non-intentional (automatic) enactment tendencies developed throughout the history of the individual, where particular stimuli trigger a specific behavior even when the individual does not instruct himself/herself to behave in such a way (Thorngate 1976; Triandis 1977, 1980). On the basis of this understanding, habit in IS usage refers to the non-deliberate, automatically-inculcated response that individuals may bring to IS usage (Limayem and Hirt 2003).

**Cultural Habit**

James (1890) states that “There is no more miserable human being than one in whom nothing is habitual but indecision, and for whom the lighting of every cigar, the drinking of every cup, the time of rising and going to bed every day, and the beginning of every bit of work, are subjects of express volitional deliberation” (p. 122). Habit is a mind-set that improves the perceptual readiness for habit-related cues, preventing an individual from being distracted and from adopting other, less efficient courses of action (Verplanken and Aarts 1999). It is a condition as a behavioral tendency; a tendency to repeat responses given a stable supporting context (Ouellette and Wood 1998, p. 55).

The culture creates patterns of behavior for different roles and the roles lay down the bases for the habits that determine individuals’ lives. As Bloch (1943) indicated, habits are predisposing tendencies to meet certain situations in particular ways in accordance with the roles operative in specific situations. Therefore, cultural habit is a culturally-fixed mode; it is also an artificial object in life. Durkheim (1911) indicates that most people live under the force and yoke of cultural habit. He continues that rules of conduct are produced under the force of cultural habits, which can become the greatest obstacles to progress. For example, a social phenomenon like old-fashioned corporal punishment constantly exists under the influence of the force of cultural habits. Weber (1922) points out that the same behavior in a group is a habit that originates from the culture of the society from which it comes. Camic (1986) also indicates that an individual can sometimes behave in ways that go beyond cultural habits. What is clear is that there exists a strong relationship between an individual’s life and the cultural habits of a group, and this holds true in different social groups.

**Knowledge Distribution in the University Domain**

Universities are the best places for the production and delivery of knowledge, and college teachers are the promoters of the production and delivery of knowledge. College teachers explore and create knowledge through academic research activities, sharing this with students through teaching activities to achieve the purpose of knowledge delivery. The exploration of knowledge, however, is an important channel through which college teachers accumulate their personal intellectual assets. Through research activities and academic presentations, they demonstrate their status in their professional field. These knowledge assets are also important elements of college teachers’ personal teaching activities.

Most traditional teaching activities take place in the classroom, where the medium of knowledge delivery often includes textbooks, handouts and blackboards, etc., with teaching content always being delivered verbally. The range of knowledge delivery is confined to the actual classroom space, with the recipients of knowledge being the students in the classroom. When IT platforms are introduced into activities of knowledge delivery and sharing, the medium, methods and range of knowledge delivery also change. Specifically, the recipients of knowledge change from a limited number of students to all possible readers that come and go on the technology platforms. In this way,
teachers’ actions become public social conduct (Huysman and Wulf, 2004) that fall under the gaze of known students and unknown others.

Therefore, using the technology platform as a new medium leads to considerable clashes in terms of knowledge delivery and methods of sharing college teachers’ knowledge as well as habits with respect to knowledge assets. In view of this, it is necessary to understand the process of change in college teachers’ cultural habits when they are faced with the challenge of embracing IT to share knowledge.

**Research Design**

**Research Methodology**

The phenomenological research method is the most appropriate way to study personal life experience (Lowenberg and Washington 1993). It allows us to impose structural analysis on the most ordinary, the most familiar, and the most self-evident incidents. The purpose is to construct a vivid description of the actions, behaviors, will, experience, etc., that are encountered in human lives (Van Manen 1990). For this reason, the present study adopts the phenomenological research method to describe systematically the life and world surrounding teachers and their lived experience of using the KSKSP.

In the study, data were collected through narrative interviews, a method of information collection in social sciences undertaken through the narrating process of the participants permitting deep exploration of the individual’s world of experience (White 1980). Unlike other methods, a narrative interview allows research participants to talk about their own life experiences in the form of impromptu narration. The beginning of an interview is conducted by asking short questions guided by specific situations. After that, the participants themselves decide on the content and the speaking style and the interview continues. In the narrating process, researchers do not impose any limit on the directions and content of speech. Josselson (1995) maintains that narration is the representation of a process, a presentation of a self-reflective internal dialogue, as well as a dialogue between oneself and the world. Therefore, the narration does not represent how facts should be recorded or the truthfulness of events, but records within a system of meaning the complicated thinking and experience of a lifetime.

**The Case**

The Taiwanese education system consists of basic, intermediate, advanced and returning education. Basic education includes kindergartens, national primary and national middle schools. Intermediate education includes vocational and senior high schools. Advanced education includes junior colleges, universities and graduate schools. The case used in this study is a college of technology, well-renowned among all the colleges in Taiwan for its IT-oriented campuses and fully integrated electronization. The FSKSP is a digital space exclusively for interaction between faculty and students. The FSKSP service for teaching became available in 2004, and was set up with Share Point software launched by Microsoft. Major functions of the platform include: sharing documents, contact information for both faculty and students, a discussion area for faculty and students, and the teacher’s personal teaching resources, etc. Each of the 260 full-time teachers in the college has his/her own exclusive interactive teaching environment. The teachers can create and alter their web-page design, upload and include supplementary material for courses; they can announce real-time messages and answer students’ questions, etc. Students are able to obtain necessary information about courses, receive real-time messages from their teachers, and ask course-related questions, etc. The major purpose in installing the platform is to create another interactive venue outside the class for the faculty and students so that knowledge distribution and sharing is not limited by time and space. Until 2008, 133 teachers in total were using the platform online, representing a usage percentage of approximately 51%.

**Sampling and Procedures**

After observing the usage of each faculty member on the FSKSP, via e-mail, we invited faculty members from different professional fields. Using the snowballing method, we continued to invite teachers who were recommended or simply mentioned by participating teachers. A final total of 16 college faculty members participated in this research. The interview period lasted for four months.
In order to elicit narratives about the life histories and daily lives of the participants, we followed the recommendations of Myers and Newman (2007), Seale and Filmer (1998), and Van Manen (1990). For example, each interview began with the open-ended question, “What was your knowledge delivery and sharing experience on FSKSP?” If necessary, to enable us to obtain a broader understanding of participants’ comments, the open-ended question was followed by more probing ones, such as “Can you explain that more?” or “What do you mean by that?”

The interviews were recorded using a multifunction digital recorder, and were transcribed verbatim immediately after each interview, to discover new narrative experience phenomena or missing links in the questions posed. This enabled us not only to include the new findings in the interviews conducted with other participants, but also to raise them the second time we interviewed the interviewees. Through repeated interviews, we hoped to achieve the desired degree of saturation and completeness in the information provided by the cases studied and between cases for the purpose of data analysis (Agar 1986).

Data Analysis

With the phenomenological research method, the purpose of data analysis lies in the systematic organization of the contents of the interviews, which allows the cause and effects of incidents, the social norms and social values hidden beneath the cultural behaviors to be made plain through participants’ narratives (Rubin and Rubin 1995). The data analysis was a bottom-up process that mainly followed the procedures described by Cohen et al. (2000). The aim of the initial phase, immersion, where we read transcripts several times and immersed ourselves in the data, was to establish an orienting gestalt of teachers’ lived experiences when using the platform. This provided an initial interpretation of the data that would drive later data coding in subsequent analysis phases (Barritt et al., 1983; Van Manen, 1984). In this phase, we identified the essential characteristics of the data from each interview (Kockelmans, 1975).

During the thematic analysis process, as an understanding of the overall text was obtained, phrases in the text were underlined and several tentative concept names were written in the text margins. Transcripts were examined line-by-line, and all important phrases were labeled with these tentative concept names (Barritt et al., 1983; Van Manen, 1984). Please refer to Figure 1 for an example of the thematic analysis.

<table>
<thead>
<tr>
<th>Tentative Concept Names</th>
<th>Partial Interview Text</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electronization is a digital era trend</td>
<td>It’s impossible to resist the trend! There is no chance for rebuff, either. With the coming of the digital era, one cannot possibly teach a class using one’s mouth and blackboard writing alone! It would be very hard for the students to respect you if you did. In the past, when there was no Internet and computer technology, a teacher could simply teach through lectures, blackboard writing, textbooks, charts or graphs at most … Teachers need to convert Internet information and digital information into appropriate teaching materials.</td>
</tr>
<tr>
<td>Students’ respect for teacher</td>
<td></td>
</tr>
<tr>
<td>Traditional teaching method</td>
<td></td>
</tr>
<tr>
<td>Converting Internet information into teaching materials</td>
<td></td>
</tr>
</tbody>
</table>

*Figure 1: Sample of the data analysis process*  
(*Concepts are given for each meaning unit. The concepts essentially are labels placed on utterances or events. These identified concepts are then further grouped into a higher abstract level called theme.*)
We then grouped together passages into themes. An example of the grouping and theme formation is shown in Figure 2. Finally, an overarching theme was built to integrate those separate themes by repeatedly examining and comparing the material both within themes and across themes, as illustrated in Figure 3.

When the coding was completed, we compared what interviewees had said, what themes were discussed, and how concepts could be understood from the context of Taiwanese culture. Finally, we constructed a textual-structural description of the meanings and essence of informants’ experiences (Kahn, 1993; Sandelowski, 1993, 1994; Moustakas, 1994).

<table>
<thead>
<tr>
<th>Theme</th>
<th>Concept/Label</th>
<th>Case</th>
<th>Meaning Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compromise in Response to IT Trend</td>
<td>Electronization is a digital era trend Students’ respect for teacher Traditional teaching method Converting Internet information into teaching materials</td>
<td>It’s impossible to resist the trend! There is no chance for rebuff, either. With the coming of the digital era, one cannot possibly teach a class using one’s mouth and blackboard writing alone! It would be very hard for the students to respect you if you did. In the past, when there was no Internet and computer technology, a teacher could simply teach through lectures, blackboard writing, textbooks, and charts or graphs at most …. Teachers need to convert Internet information and digital information into appropriate teaching materials.</td>
<td></td>
</tr>
<tr>
<td>Compromise in Response to IT Trend</td>
<td>Students’ respect for teacher Traditional teaching methods IT is advancing</td>
<td>The students are going to criticize you if you still use black-and-white posters. There is nothing you can do but to make changes. Information technology is advancing; the schools are also changing.</td>
<td></td>
</tr>
</tbody>
</table>

Figure 2: Sample of the data coding process - Building Themes

<table>
<thead>
<tr>
<th>Overarching Theme</th>
<th>Theme</th>
<th>Concept/Label</th>
<th>Case</th>
<th>Meaning Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cultural Habits Change Process Triggered by Use of IT</td>
<td>Compromise In response to IT Trend</td>
<td>Electronization is a digital era trend Students’ respect for teacher Traditional teaching methods Converting Internet information into teaching materials</td>
<td>It’s impossible to resist the trend! There is no chance for rebuff, either. With the coming of the digital era, one cannot possibly teach a class using one’s mouth and blackboard writing alone! It would be very hard for the students to respect you if you did. In the past, when there was no Internet and computer technology, a teacher could simply teach through lectures, blackboard writing, textbooks, and charts or graphs at most …. Teachers need to convert Internet information and digital information into appropriate teaching materials.</td>
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<tr>
<td></td>
<td>Compromise In response to IT Trend</td>
<td>Students’ respect for teacher Traditional teaching methods IT is advancing</td>
<td>The students are going to criticize you if you still use black-and-white posters. There is nothing you can do but to make changes. Information technology is advancing; the schools are also changing.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Dignity in Expertise</td>
<td>Students “teach” teacher to work on the FSKSP I am a professor</td>
<td>The school KM administrators sent student workers to “teach” teachers to learn how to work on the sharing platform [FSKSP]. They should refrain from the word “teach,” but rather, “assist,” the teachers to establish it. When they use the word “teach,” I am a professor, if people hear that I have to be taught, then I am done with teaching!</td>
<td></td>
</tr>
</tbody>
</table>

Figure 3: Sample of the data coding process- Building Overarching Themes*  
(*The overarching theme — “Cultural habits change process triggered by the use of IT” is built to link the themes “Dignity in expertise”, “The fear of making changes and not making changes”, “Compromise in response to IT trend”, and “Going forward or going back.”)
Findings

The study shows that delivering knowledge to and sharing knowledge with students through the FSKSP differs enormously from the long-established verbal knowledge sharing in classroom lectures. In choosing to use the FSKSP and making changes to the interaction between faculty and students, the teachers go through the following stages: protection of professional dignity and expertise; panic about whether or not to make changes; compromise in response to the trends in information technology, and hesitation about whether to continue or to turn back.

Dignity in Expertise

“Teachers are experts. They should be knowledgeable, have superior intelligence and know everything.” These are the general conceptions of teachers held by people in modern society. Teaching has been a respected profession; hence, in the face of external pressures, teachers tend to question why they should follow an imposed code:

The school KM administrators sent student workers to “teach” teachers to learn how to work on the sharing platform [FSKSP]. They should refrain from the word “teach,” but rather, “assist” the teachers to establish it. When they use the word “teach,” I am a professor, if people hear that I have to be taught, then I am done with teaching!

Teachers are quite used to the idea that being a teacher means they should “be able to do everything”. Moreover, college teachers enjoy hyper-autonomous status; they do not allow other people to interfere with their mode of teaching. The dominating concept on college campuses is for the professors to rule the school, and such a concept endows college teachers with hyper-level autonomy.

Teachers serve as an important bridge in the sharing and delivery of knowledge; IT, on the other hand, is the symbol of progress. IT is regarded as an aid for teachers to share their knowledge. However, teachers are not of the same opinion when they share knowledge through IT:

I can teach with this [FSKSP]. I can still teach without this [FSKSP]. Frankly, there is not much difference with or without it. ... If I can use other mechanisms to guarantee my teaching quality, do I have to use this platform [FSKSP]?

The confidence of teachers in their own teaching methods makes them unwilling to change the teaching methods they have been used to.

The Fear of Making Changes and Not Making Changes

The knowledge availability and delivery is ever-increasing. Teachers are becoming aware of the fact that students are doing better than the teachers themselves in some ways; students have a considerable amount of knowledge already. In the past, the teacher always knew more than his students .... But it is different now. Do you think students are always inferior to teachers? It is not necessarily so! Teachers are probably superior in some theories, but may be inferior when it comes to the operational parts.

If a teacher can neither make progress in his traditional teaching methods, nor enhance his own position of superiority through digitalized teaching materials, would it lead to their being unable to teach the students anything? Teachers are beginning to worry that they might lose their core value as teachers.

If a teacher can teach very well with traditional methods, then they will continue to survive; if they cannot teach well with traditional methods, and cannot make digital teaching material either, then they have nothing left but a mouth!

Yet, for teachers, knowledge is their most important asset. If they put it on the Internet, and make their knowledge easily accessible, then what is their professional value? Exploration of knowledge is an important way for teachers to accumulate their assets in an environment such as the academic world; teachers consider it necessary to protect what belongs to them, because without their unique knowledge, they lose their value:

Teachers certainly don’t want others to get their material easily. We all hope to get other people’s information easily, but we don’t want others to get our information. This is human nature. In the
In the academic world, basically, I think teachers are rather stingy. The teaching materials that I have been collecting and accumulating over the years are ready for publishing in a book. However, if someone pulls a fast one on me and publishes it, I could not possibly prove it is mine.

Once a person’s own knowledge assets are made public on the Internet, the teachers fear that the knowledge they have striven so hard to accumulate will be stolen by others and lose its value. Furthermore, in traditional teaching methods, the recipients are students only, and the range of knowledge transfer is limited to the confines of the classroom. As a consequence, teachers do not have to worry about violating other people’s intellectual property rights. However, when the teaching material is placed on the Internet, not only is it accessible to students; accessibility extends beyond the classroom, prompting teachers to begin to consider the problem of their intellectual property being violated by unknown others on the platform:

I hide nothing when I teach my own students. But I don’t want all the people in this country to retrieve my professional knowledge from the platform and go!

Teachers worry that their own knowledge will be taken; they also worry about violating other people’s knowledge assets:

Sometimes, for the sake of teaching, we download commercials, videos or other people’s articles. There is no question of copyright when I play them in the class because it may last only 3-5 minutes and there will not be any record left. I do not have to worry about playing the class materials I download from the Internet. However, if I put them on the sharing platform, it should be a concern. This is what worries me.

Compromise in Response to the IT Trend

Teachers struggle between the role given to them by society, which gives them pride in their profession, and their heart-felt concern about being made redundant. They force themselves to try new ways and change their methods of sharing with which they have been familiar for so long.

You might have been able to use some material for ten years in the past, but not now. Without further learning, things cannot be used after one or two years. Can a teacher teach students with what he learned on the doctoral program until his retirement? It is just not possible.

Teachers may also feel that they have insufficient knowledge, and progress must be made in this respect. As a teacher, the only option is to continue to learn.

We can continue to learn through reading ... we have doctoral degrees, we are teachers, and have no option but to learn!

As there are now many channels through which students can acquire knowledge, teachers can no longer rely on invariable content alone. Teachers have to learn new knowledge and blend in updated, everyday reality to make their teaching content extend the students’ current knowledge.

The era of electronization has arrived ... no comprehension of or proficiency in IT is like losing a connection with this era. It is almost as if you cannot go out of the door, and there is no way you can interact with other people.

As teachers, they view electronization as a trend with which they are obliged to keep apace.

It’s impossible to resist the trend! There is no chance for rebuff, either. With the coming of the digital era, one cannot possibly teach a class using one’s mouth and blackboard writing alone! It would be very hard for the students to respect to you. In the past, when there was no Internet and computer technology, a teacher could simply teach through lectures, blackboard writing, textbooks, and charts or graphs at most .... Teachers need to convert Internet information and digital information into appropriate teaching materials.

The students are going to criticize you if you still use black-and-white posters. There is nothing you can do but to make changes. Information technology is advancing; the schools are also changing.
With the changes in the teaching environment, a teacher can no longer depend exclusively on blackboard writing, textbooks and their voice. It seems that only by casting away the old habitual teaching methods and learning to use the new teaching-enhancement tools, can teachers make students appreciate their efforts.

**Going Forward or Going Back**

After initial hesitation, teachers begin to feel that the use of the FSKSP could be helpful in teaching, and so start to change their long-held sharing modes. They tend to think that they should use the platform if they want to be “good teachers.”

> *If you would like to be a good teacher, then, of course, this platform offers itself as something that you can do now, but could not do before.*

The distance between the teachers and students is lessened after using the platform:

> Students are more outspoken on the platform than they are in the classroom. There is a great difference! I am more like a friend on FSKSP, yet, in the class, I am a teacher! The distance with the students is lessened.

The feedback from students provides the best encouragement for teachers. Increased enthusiasm from the students promotes greater effort among teachers to improve their teaching.

> Now, when they (students) notice what I have posted and changed on my webpage on FSKSP, they say, “Wow, you’ve made the changes to the setting of the webpage!” I find that students visit my webpage and read what I share on FSKSP. I will do my best to maintain my webpage, constantly updating it so that it can be more informative and valuable.

However, for some teachers, having used the platform, they feel unable to make the changes, so they revert to the old sharing modes in teaching with which they have been familiar for so long:

> Its effects are really not so good. So if I were to choose, I would not use it. I have been using it for more than two semesters. If I can choose in the next semester, I will be more inclined not to use it.

After using the FSKSP for a period of time, the teachers regard the making of teaching material as time-consuming. They feel that students neither use the platform, nor know how to respond, leading to less effective results than expected. All of these factors lead the teachers to choose to abandon the changes and return to their old teaching methods:

> The ways of preparing teaching material are different. In the past, I simply made copies for students; now everything has to be made into digital files. The time spent is more than two or three times what it used to be. The price is much too high! When I found that my students did not use the platform often, I started to feel it was a waste of time. I wondered, ‘who am I making all these for?’

Teachers spend considerable time on preparation, hoping that the students will improve and obtain knowledge through their efforts. However, when they discover that the students do not even read the material, the feeling of loss prompts their decision to discontinue. In addition, students do not respond to the platform, it being only the teachers who upload material with no kind of feedback or payback. As there is no way of knowing how students are using the platform, teachers’ reluctance to use it increases.

> I thought it was right; students could read the materials I put on the platform at any time. But this was not the case. Students stopped coming to the class, they could simply download from the platform as everything was there. Students skipped classes without feeling guilty.

The FSKSP brings convenience for students as well as negative impacts for teachers. Students begin to skip classes; they refrain from taking notes in the class, and stop buying books because “everything is on the Internet.” This is also one of the reasons for teachers’ deciding to abandon the platform and to return to their old teaching methods.
Conclusion and Discussions

Considerable problems arise when a familiar, well-tried and tested teaching design is changed, through the scheme of a FSKSP, to one that is utterly different. The elevated status of college teachers in their professional fields has endowed them with excellent qualities and confidence in their own teaching methods. However, with the arrival of IT, loaded with the symbols of “efficiency,” “modernity,” and “strength,” and complemented by all kinds of commercial publishing, professional discussion groups and the grapevine of personal Internet networks, the notion that the “solution is in the IT” has taken root in our system of thinking and ideology. As a consequence, college teachers have been forced to make adjustments to their teaching mode in response to the changes. Such adjustment has been made through a process characterized by conflict and tension between the professional values of college teachers and the use of IT. This conflict is found in the following experiences of teachers: the shaken social status of college teachers, the threats to professional and economic value of knowledge assets, concerns over protecting personal intellectual property and infringement. Through our awareness of this, it is possible to make the following proposals for improvements: for college administrators, it is vital that they take into account potential for the FSKSP’s technical subsystem both to threaten and to enhance teachers’ social image/status so that the dignity of the role of teacher can be retained in the FSKSP context; for system designers, the technical subsystem should allow teachers to determine whether their teaching activities are open to public view or not, providing them with control over their activities in respect to other users on FSKS.

Theoretically, our research makes several contributions to the study of habit (e.g. Limayem and Hirt 2003; Kim and Malhotra 2005; Limayem et al. 2007). First, our findings highlight the importance of cultural habits in explaining how, why, and when the technical subsystem interacts with the social subsystem (teachers’ cultural beliefs, attitudes, and skills) during the challenge of FSKSP implementation. This helps in integrating the technical and social subsystems of FSKSP as a whole. Second, we identify cultural habit as a culturally-fixed mode that drives an individual’s social practices in a group and in the particular context. In interpreting an individual’s information systems usage behavior, it is necessary to think beyond the previous perception of habit as automatic behavior (Limayem and Hirt 2003; Kim and Malhotra 2005; Limayem et al. 2007). Third, from the cultural habit perspective, our research explores the extent to which the role of dignity (i.e. the teacher as an expert), the degree to which IT both threatens and enhances teachers’ social status, and the level of compromise in response to the IT trend serve as the antecedents of the social subsystem in predicting teachers’ intention to use the knowledge sharing system. This finding not only contributes to the habit model research stream, but also adds value to the comprehensive model proposed by Brown (2010), which integrates social presence theory, channel expansion theory, and the task closure model with UTAUT to explain the adoption and use of collaboration technology.

Methodologically, our research has adopted phenomenology as the paradigm for studying teachers’ FSKSP-use experiences. This methodology has provided us with an approach appropriate for researching the complex world of human experience capable of accommodating non-empirical data such as values, beliefs, and feelings. The intent in the research was to use a contextually-based, holistic psychology that views human beings (teachers) in non-dualistic terms, and that seeks to attain a first-person (teachers as the subjects) description of lived-experience (FSKSP practice) (Giorgi, 1983). From this perspective, the meaning of FSKSP practice has been situated in a current experiential context and has been related in a coherent way to the FSKSP participants’ lived-word (Sartre, 1962). Our study has utilized phenomenological philosophy and research methods for returning teachers’ FSKSP experiences to educational technology and social research.

References


Transforming Online Learning through Narrative and Student Agency

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ABSTRACT
Efforts to improve online learning have focused primarily on the technology platform for delivering educational content and supporting student discourse. In this paper we describe an alternative approach that invokes two powerful forces behind human learning: narrative and agency. Each of these constructs and their potential impacts on learning is reviewed, and the design of a large-enrollment online undergraduate course that leverages these elements is described. A study of student learning and engagement was conducted using surveys and an analysis of student projects on 96 students enrolled in the new course. Surveys were also administered to 129 students taking a traditional online course in other departments to provide a comparison data set. Results of this study indicated significant benefits of employing narrative and increasing student choice on interest and perceived relevance of the course material, critical thinking, and the acquisition of design skills. We conclude by discussing the implications of these results on the design of online instructional environments generally, and call for the increased adoption of interactive storytelling elements into web-based learning platforms.

Keywords
Online learning, Narrative, Agency, Undergraduate education, Emerging media

Introduction

As access to broadband technologies increases worldwide, online educational platforms continue to spread across all variety of learning environments, particularly within colleges and universities. In the US in 2009, more than 5.6 million students were enrolled in at least one online course in the fall term, an increase of nearly a million students from the previous year. This outpaces by far the growth of overall enrollment in higher education (Allen & Seaman, 2010). With the rapid growth of online learning has come increased attention to ways of improving the mechanisms of delivery. Efforts thus far have focused primarily on tools for communication (student-instructor, student-student, etc.) and enhancing the technologies for carrying out course activities (demonstrations, assessments, etc.). Recent research has reported on online design initiatives including new tools for supporting student collaboration (van Joosten, de Jong, Lazonder, Savelsbergh, & Manlove, 2005), small group discussion (Suthers, Vatrapu, Medina, Joseph, & Dwyer, 2008), and scaffolding student questions (Yu, 2009). Technological advances have also made it possible to augment online courses with high resolution lecture recordings, video conferencing capabilities, and virtual interactions in environments such as Second Life.

While these are all potentially useful developments for improving online education, we see them largely as attempts to replicate face-to-face instruction and traditional classroom-style practices. The disadvantage of this approach is the propensity to neglect the unique affordances of online platforms for promoting learning and cognition. In other words, we may be better served by inventing new forms of instruction that exploit what online platforms do particularly well, rather than continuing “best we can” approximations of tried and true classroom pedagogies (see Mishra (2002) for similar lines of argumentation). For example, the spatial features of interactive simulations that can be displayed on computers and often delivered online have special properties for learning difficult concepts in science (Lindgren & Schwartz, 2009). Another learning affordance of online technologies is their capacity to deliver personalized interactive experiences. Two constructs in particular that characterize these experiences are narrative and agency. Narrative is the causal sequence of events that defines the experience—the expression of what happened in story form. Agency is the power of the individual to choose what happens next. Together, these two constructs create an experience that is both self-determined and purposeful. The capacity of digital technologies to produce dynamic content and create detailed records of user pathways through this content makes them uniquely suited to support these two elements (see Murray, 1997; Manovich, 2001).

Our objective is to investigate the effects of an online course where narrative and student agency are prominent design features. For the purposes of this initial design study we will not attempt to parse out the individual effects of these elements, rather we will explore whether or not the two in tandem have a demonstrable impact. Our hypothesis
is that the inclusion of these elements will lead to substantial improvement in student learning and engagement compared to traditional online course instruction. We begin with an examination of the research literature on how narrative and agency each influence learning. Next, we describe the design of an online course where each student becomes the protagonist in a story about acquiring their dream job working for an eccentric billionaire. Approximately 100 students enrolled in the initial run of the course, and results from student surveys and an analysis of student projects will be presented. We conclude with a discussion of design implications and future applications.

Narrative and Learning

The narrative form and its relationship to learning has captured the interest of learning theorists working from a variety of disciplinary backgrounds including cognitive science, computer science, and neuroscience (e.g., Meehan, 1977; Minsky, 1985; Schank, 1995; Young & Saver, 2001; Mar, 2004; Jahn, 2004; Ryan, 2010). As an intuitive form of communication that is used from parent to child even before higher order language skills such as reading and writing are obtained, its usefulness for learning about the world is obvious (Nelson, 1989). For instance, Bruner (1991) discusses the fundamental nature of storytelling as a cognitive device for organizing human experiences and perception. He explains that narrative cognition and discourse are linked in a complex way, noting that “as with all prosthetic devices, each enables and gives form to the other, just as the structure of language and the structure of thought eventually become inextricable” (p. 5). Despite this difficulty of separation, he proceeds to identify ten features of narrative that assist in the construction of knowledge, each with an explanation identifying how those features aid in cognition. Of particular interest to cognitive scientists is the feature of hermeneutic composability, in which particular narrative events must be “constituted in the light of the overall narrative” (p. 8) and then interpreted by a human’s knowledge processing system such that they exist as a whole with the other narrative elements (characters, actions, and environments).

Graesser and colleagues (1994) further studied the ways in which readers of narrative texts generate inferences and construct a situation model (Morrow, Bower, & Greenspan, 1988; see also Wilson et al., 1993), or a mental representation of the narrative, in order to comprehend those texts based on existing knowledge. Their work identifies not only the textual level of inferences employed during sentence comprehension, but also the deeper thread of thinking done when a reader examines cause and effect relationships, character motives, and the global message (i.e., point) of a story. The importance of this holistic understanding of stories even for young children is clear in an analysis of popular “teach your child to read” books such as Engelmann, Haddox, and Bruner’s Teach your child to read in 100 easy lessons (1983). Here, early lessons stress not only sound recognition, enunciation, and writing, but also character identification, motive identification, and plot recognition. The latter three elements are assessed through the child’s reading the sentences and then looking at a picture depicting those sentences and answering questions about the story and the picture.

Given the importance of causal pattern and structure in narrative communication, it makes sense that computational systems can augment narrative learning systems in interesting and useful ways. For example, one might construct a narrative learning system that calls upon a repertoire of various plot structures that are particularly well suited for different learning objectives. An example of this is a system that returns “quest”-type plots with particular geographic locations used within the story in order to explore geography or history lessons in an embedded context. Narrative backbones for computer simulations and video games have also been developed based on generative heuristic questions adapted from studies of narrative (McDaniel, Fiore, & Nicholson, 2010). Other computational narrative systems; such as automated story generators, agents, story database systems, and interactive fiction systems; are detailed by Mateas and Sengers (2003) under the theoretical framework of narrative intelligence.

Student Agency

A second element of online learning environments that we explore in our design is the degree of agency allotted to students enrolled in the course. We can define agency as “the capability of individual human beings to make choices and act on these choices in a way that makes a difference in their lives” (Martin, 2004, p. 135). Epic debates have been waged in sociology and philosophy on the relative influence of agency vs. the “structure” of social systems in determining human behavior (e.g., Hays, 2004), but we are concerned here specifically with the question of whether instructional environments that empower students to make consequential choices enhances learning compared to
those that allow for less agentic action. Some researchers have examined agency as an individual trait and have described its role in student learning styles and its interaction with online instruction (e.g., Greener, 2010), however, the focus in this paper is on agency and choice as something that can be elicited generally through interface and environment design.

The notion of agency as contributing to cognitive processes involved in learning comes primarily from the Piagetian notion of constructivism (Piaget, 1967) where knowledge is seen as “constructed” through a process of taking actions in one’s environment and making adjustments to existing knowledge structures based on the outcome of those actions. The implication is that the most transformative learning experiences will be those that are directed by the learner’s own endeavors and curiosities. Bandura (2001) highlights the role of agency in the self-regulation of learning: “The core features of agency enable people to play a part in their self-development, adaptation, and self-renewal with changing times” (p. 2). Giving students the sense that they have control and the power to affect their own learning is one of the great challenges of contemporary education.

Agency can shape both the process and the outcomes of student learning. The most notable effect on the process of learning is that the sense of personal agency typically has a strong motivational component (Ford, 1992; McCombs & Marzano, 1990). People are more driven to achieve the agendas they set for themselves. Feelings of agency will often lead people to work harder and to persevere when confronted with challenges. An important motivational component of human agency is perceived self-efficacy (Bandura, 1982). Not only does agency come with the will to achieve, but also the belief that one can achieve. As for the outcomes of learning, agency and self-regulation can produce learning experiences and knowledge that a learner perceives to be more self-relevant (Wolters, 1998; Zimmerman, 2001). This is important because it may affect the likelihood that the learned information is retrieved or is transferred to applicable contexts. Personal relevance may also make it easier for a learner to situate new learning within existing knowledge structures by making connections to previous experience. The overall result is learning that is more flexible and adaptive because it was conceived under the conditions of specific personal needs and aspirations.

Eliciting a sense of agency in educational environments, particularly in formal contexts such as a university, is not a trivial undertaking. Empowering and managing the variable learning pursuits of each student in a large class is not a reasonable burden to place on an instructor. Agency is not the same as freedom; one cannot expect that students will naturally embark upon meaningful and achievable learning inquiries simply by reducing oversight and lessening the restrictions on student activity. There are, however, techniques for amplifying student agency that have found success even within traditional educational settings. One is the use of questioning and engaging students in a dialog that forces them to defend (and hopefully understand) a set of arguments, often referred to as the Socratic Method (e.g., Gose, 2009). An instructional approach referred to as problem-based learning (Hmelo-Silver, 2004) similarly puts a student in an active role by presenting them with an ill-structured problem that must be solved through the student’s ingenuity and initiative. Finally, there have been recent efforts to include more elements from informal education, such as free-choice learning (Falk & Dierking, 2002) in formal educational experiences, where students can make decisions about what, where, and with whom to learn. It is this latter element of choice that fuels the design of the online course described below. A large part of agentic learning is the ability to make meaningful choices that impact our learning, and some have suggested that looking at the products of these choices can serve as valuable tools for assessment (Schwartz & Arena, 2009).

Computer technologies present new opportunities for drawing out and leveraging student agency. One of the ways that technology accomplishes this is by personalizing the learning experience, allowing the student to work at their own pace and being responsive to individual needs, such as found in intelligent tutoring systems (Corbett, Koedinger, & Anderson, 1997). Other technologies create agency by putting students in the role of a teacher (Biswas, Leelawong, Schwartz, & Vye, 2005) or by serving as embodied communicative partner (Lee, Stiehl, Toscano, & Breazeal, 2009). Here we attempt to facilitate student agency by presenting students with consequential choices and adapting both the course curriculum and assessment to accommodate those choices.

Course Design and Rationale

In order to build a viable curriculum around sustained student choice and the unfolding of a narrative backstory, we opted to design a survey course that explores the field of digital media. Our course, named “Adventures in Emerging
Media” (AEM), was designed as a junior-level elective with no pre-requisites. We hoped to attract both digital media majors as well as students outside the department interested in learning more about the field.

We designated seven weeks of the 16-week course as “branching” weeks in which students could choose the learning modules they wished to participate in for that week. Each learning module was designed and delivered by an instructor with expertise on the assigned topic. Most of the modules were anchored by video recorded multimedia presentations where the instructor spoke directly to the camera or over a media-rich slide presentation. The remaining nine weeks of the course were used to present content on topics we felt were fundamental and should be taken by all students (e.g., understanding how to design for immersion) or to engage in common activities important to the course (e.g., performing a peer-review of class projects or taking course exams). Overall, there were 26 different learning modules created for the course.

During the first two weeks of the course, students uploaded an original project of their choice along with a hypothetical job application for a corporate position at an organization run by fictional media mogul Nelson Von-Berners. The student job application and Von-Berners storyline served as the narrative backdrop of our course. Von-Berners was scripted as a whimsical inventor who is a bit scatterbrained, but who also clearly fits the professor character archetype suitable for the humorous story we wanted to tell. Key story components were released to students at four points in the semester including at the very beginning of the course and the very end of the course. Each narrative fragment consisted of an animation that featured Von-Berners giving instructions or encouragement from various exotic locations (his office in Greece, a jeep ride in Dubai, and even during putting practice on the surface of the moon). It was important that these story pieces be compelling, so we invested in the creation of four cartoon-style animations created in Adobe Flash and using professional voiceover actors. By releasing the story in segments rather than all at once through an extended cut scene, we hoped to harness some of the same motivational effects as contemporary, story-driven videogames that are crafted in the same fashion.

In terms of learning content, rather than focusing on a particular tool or technology for each week (e.g., Final Cut Pro), we identified a sequence of modules assigned to particular weeks that would lead the student through various paradigms that frame emerging media in particular ways. For example, one week was designated the “history” week and focused on historical developments in ideas and technologies that impacted the field of digital media. Similarly, a “conceptual” week (Figure 1) allowed students to engage in that week’s materials through exploring creativity, algorithmic design, or audience analysis (Figure 2). In the second half of the course, modules covered applied skills that students could use for the second round of original digital creations submitted at the end of the course.

The course ran atop our own Learning Management System that we developed using Internet scripting and database technologies (PHP and MySQL). This ensured that we could embed assessment instruments such as pre- and post-semester surveys as seamlessly as possible while also allowing students to take examinations that targeted only the modules they had selected for a particular week. Students completed midterm and final examinations; their applied projects were graded by an instructor based on a rubric developed for this purpose.

A Study of Student Engagement and Learning

Methods

A review of research on online instruction found that most studies are descriptive and exploratory accounts of a particular platform’s features (Tallent-Runnels et al., 2006). Those studies that do attempt to quantify an online platform’s effects tended to do so by focusing on one feature of the platform and constructing measures to specifically evaluate that feature. For example, Stanley (2006) examined the use of assignments or quizzes as a means of weekly assessment in two online university public health courses. To compare these approaches the author looked at scores on exams and administered a short survey that asked students how they felt about the online assessments. In the current study we sought to compare the effects of more macro-level design decisions, namely giving students an agentic role in a pervasive course narrative compared to the more traditional approach of positioning students as recipients of knowledge transfer. Implementing our narrative- and agency-driven design involved multiple features—module choice, adaptive exams, story reinforcing animations, etc. Evaluating the full effects of this approach demanded a broad range of measures that touched on all aspects of the student learning experience. Our intent was not to validate the inclusion of isolated features of online courses, but rather to examine...
whether the adoption of a novel design scheme showed promise for widespread improvements in student learning and engagement.

![Figure 1: Example of student choice feature (course menu system and sample week)](image1)

![Figure 2: Example of student choice (learning content selection module)](image2)

**Participants**

Data was collected from student projects, examinations, surveys, and the online activity of 96 students enrolled in the first offering of the AEM course. Most of these students were in either their 3rd or 4th year of an undergraduate degree program; 37% of students were female. Eighty of these students were declared “Digital Media” majors, while the remainder of these students came from other departments within the university seeking elective credit. This study also included students from 3 other large online courses taught at the same university. A total of 129 students from these courses completed the post-survey. These students represented over 20 different academic majors within the university; of the students reporting their gender, 58% indicated that they were female.
Engagement Surveys

Surveys inquiring about student interest and engagement with course topics were administered both prior to instruction and immediately after the course had ended. The surveys probed several areas including perceptions of the difficulty and importance of course topics, the kinds of skills that students believed they were acquiring by participating in the course, and the types of thinking skills and mental activities involved in the course. The latter of these questions were modified from the 2010 National Survey of Student Engagement (NSSE). The other questions were developed through consultation with experts on online course assessments, and although the wide range of topics covered in the survey meant that it did not lend itself to a split-half analysis, we adhered closely to guidelines for increasing the reliability of our survey instrument (e.g., Bordens & Abbott, 2011). All surveys were delivered as a web form using the AEM course management system. Survey results were stored in secure database and exported to spreadsheet format for analysis.

Many of items on the survey were fairly general questions that could be asked of almost any online course. Thus, a subset of questions from the AEM survey was administered to 3 other large online courses taught at the university during the same semester. We were interested in whether or not the unique attributes of the AEM course would show different patterns of engagement compared to a variety of other courses taught in the traditional manner of online instruction. All three of the comparison courses were taught using the Blackboard CMS. These courses were selected because they represented a range of university departments (2 in Arts and Humanities and 1 in Engineering and Computer Science) and because they had a similar number of enrolled students and a comparable “survey of topics” course structure. Students in each comparison course were emailed a unique web link so that they could complete their survey via the same online system as the AEM students.

Creative Projects

Survey questions that asked the AEM students to rate their own competence on a set of emerging media skills, before and after the course, offer some limited insight into the kind and quantity of learning that students experienced. In order to gain a more direct measure of learning, however, we examined changes in the quality of students’ creative work over the course of the semester. In Week 2 students were asked to make an original digital media creation as part of the interview for their “dream job.” For the final project in the course students were again asked to submit an original digital creation that leveraged the skills they had acquired during the previous several weeks. In both cases the specifications for the project were fairly open-ended; students had the option of creating any number of different media objects such as a webpage, an interactive story, a game design, a product logo, etc. Following the cautious of Nitko (1996) regarding ambiguity about course project assignments, we followed Romero and Haughton’s (2010) Course Improvement Matrix and gave students a detailed rubric so that there were clear guidelines about what elements needed to be included. The rubric consisted of 5 broad categories that pertain to the fundamental design goals for digital media: technical competence, interactivity and engagement, aesthetics and artistic design, message and consideration of audience, and professionalism. In order to assess learning within the student projects we assigned a score on a 0 to 4 point scale for each of the 5 categories. The categories were general enough that student projects could reasonably be scored regardless of the creative medium used, and most importantly the rubric does not emphasize the level of effort put into the creation—a well-crafted digital project made quickly still had the potential to score high in all five areas. One could argue that students will naturally spend more time and energy on a final project than on one assigned at the beginning of the semester, and we did not want to bias our evaluation of competence in emerging media design skills.

Results

Engagement Surveys

A total of 200 unique students participated in these surveys; 71 of these students were from the AEM course and 129 were from one of the three comparison courses. The completion rate for the AEM students was especially high because the survey was integrated with the course platform, giving us direct lines of communication with these students (and the opportunity for multiple reminders). The number of students in each of the comparison courses completing at least one survey depended on the total number of students enrolled, ranging from 130 to 225.
**AEM Course Features.** A subset of post-survey questions was given only of the AEM students. Two of these questions asked students directly about the primary design features of the course: agency and narrative. Students were asked to indicate the degree to which they felt having the ability to choose learning modules was a positive feature of the course. Over two thirds of these students rated this feature as extremely positive. Less than 10 percent of students rated this features as somewhat positive or not positive. When asked about the “dream job” narrative, nearly 70 percent of students rated the course as being mostly positive or extremely positive. Two additional questions asked about specific components of the course that supported the narrative and agency features. One question asked about the adaptive exams, which facilitated student choice by limiting the assessments to the chosen modules. The other question asked about the periodic animations which were the primary means of bolstering the course narrative. These components showed similar patterns of positive responses, particularly the adaptive examinations which received a 69% extremely positive rating. Table 1 shows the full distribution of responses on the AEM course features.

<table>
<thead>
<tr>
<th>Course Feature</th>
<th>Number of Responses (N)</th>
<th>Extremely Positive</th>
<th>Mostly Positive</th>
<th>Somewhat Positive</th>
<th>Not Positive</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Agency: Ability to Choose Course Modules</td>
<td>71</td>
<td>67%</td>
<td>24%</td>
<td>3%</td>
<td>6%</td>
</tr>
<tr>
<td>1.1. Adaptive Exams</td>
<td>71</td>
<td>69%</td>
<td>20%</td>
<td>5%</td>
<td>6%</td>
</tr>
<tr>
<td>2. Narrative: Pursuing Your Dream Job</td>
<td>71</td>
<td>31%</td>
<td>38%</td>
<td>24%</td>
<td>7%</td>
</tr>
<tr>
<td>2.1. Animations</td>
<td>71</td>
<td>31%</td>
<td>34%</td>
<td>25%</td>
<td>10%</td>
</tr>
</tbody>
</table>

**Student Perceptions.** In the post-survey we had all students in the study respond, on a scale from 1 to 7, to a set of 11 statements about their perceptions of the course and its ability to engage them in learning (e.g., “I’ve learned interesting things in this course that I did not know previously”). The variability of student responses to these questions was generally quite high, such that there were not many meaningful differences between the AEM and comparison courses. This is not surprising given the differences in instructor, content, etc. across the 4 courses in this study. There was, however, a clear and consistent pattern in the responses to the statement: “This course has affected the way that I think about my career goals.” The responses from the AEM students on this post-survey question was significantly higher compared to the comparison courses, $F(1, 198) = 20.14, p < .001$ (See Figure 3). This result strongly suggests that the course narrative—pursuing one’s dream job—permeated student thinking about the course and its impact on their learning.

![Figure 3: Average student responses to survey question about career impact](image)

**Involved Mental Activities.** An especially insightful set of student responses came from questions asking students to report on the degree to which they felt the course elicited certain types of mental activities outlined in the 2010 NSSE survey: Memorization, Analysis, Synthesis, Making Judgments, and Application. We believe that these activities speak to the strength of the agency manipulation as some of these activities can be thought of as more passive than others. For example, memorization is certainly an important part of knowledge acquisition, but it often
is not sufficient to produce the robust learning sought after in contemporary education (e.g., Evensen & Hmelo, 2000). Table 2 shows student frequency reports for three of these activities: Memorizing, Analyzing, and Applying. The distribution of these responses differs significantly for the AEM course compared to students in the other 3 courses as indicated by the results of Pearson Chi-Squared tests. Students in the AEM course reported less memorization, with 42% responding very much or quite a bit compared to 61% in the comparison courses. In contrast, 65% of AEM students responded very much or quite a bit when asked how much they engaged in analysis, compared to 49% for the comparison courses. The strongest difference came for application where 72% of students in the AEM course reported the highest levels compared to only 39% for the comparison courses. By converting these ratings to a numerical score (1 through 4) and performing an ANOVA we found a significant effect of condition on students’ perceived levels of application, $F(1, 198) = 22.25, p < .001$. By giving students the opportunity to choose their learning modules and work on assignments and projects that interested them, we hoped to provide an engaging learning experience that would have a more substantial impact on a student’s understanding and skills in this domain. Attainment of this objective is supported by the student perceptions that they performed more critical analysis and applied learning, and less rote memorization.

Table 2. Student Reports of Mental Activities Involved in their Online Course

<table>
<thead>
<tr>
<th>Mental Activity</th>
<th>Condition</th>
<th>Number of Responses (N)</th>
<th>Very Much</th>
<th>Quite a Bit</th>
<th>Some</th>
<th>Very Little</th>
<th>$X^2$</th>
<th>$p$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Memorizing</td>
<td>AEM</td>
<td>71</td>
<td>20%</td>
<td>22%</td>
<td>41%</td>
<td>17%</td>
<td>10.89</td>
<td>.012*</td>
</tr>
<tr>
<td></td>
<td>Comparison</td>
<td>129</td>
<td>29%</td>
<td>32%</td>
<td>19%</td>
<td>20%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Analyzing</td>
<td>AEM</td>
<td>71</td>
<td>21%</td>
<td>44%</td>
<td>28%</td>
<td>7%</td>
<td>9.86</td>
<td>.020*</td>
</tr>
<tr>
<td></td>
<td>Comparison</td>
<td>129</td>
<td>25%</td>
<td>24%</td>
<td>34%</td>
<td>17%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Applying</td>
<td>AEM</td>
<td>71</td>
<td>30%</td>
<td>42%</td>
<td>20%</td>
<td>8%</td>
<td>21.85</td>
<td>&lt;.001**</td>
</tr>
<tr>
<td></td>
<td>Comparison</td>
<td>129</td>
<td>15%</td>
<td>24%</td>
<td>31%</td>
<td>30%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* $p < .05$, ** $p < .005$.  

![Figure 4](image)

**Pre/Post Student Self-Ratings of Emerging Media Skills**  
(7 = Very Confident)

**Skill Development.** The final component of the survey questions that we will discuss here are a set of questions administered only to the AEM students concerning their perceived skill levels in 17 areas related to emerging media. Both prior to instruction and after the course was complete, we asked students to rate their own competency, on a 1 to 7 scale, in areas ranging from social media to design project planning to using 3D modeling software. The sample average was higher for the post-survey responses on 14 out of 17 skill areas, and for these 5 skill areas there was a statistically significant effect favoring the post-survey as indicated by a paired-sample t-test: creating wireframes, creating 3D models, project planning methodologies, media business plan development, and project leadership skills.
Figure 4 shows the average pre and post ratings for these 5 skill areas plus one additional area that had a marginally significant effect. It is not entirely surprising that judgments of competency would improve from the beginning of the course to the end of a course, but it indicates that the students had a broad perception of overall learning. It is worth noting that students were only required to do a subset of course modules, so the fact that several of the related skill areas are showing average improvements for all students in the course suggests that many students may have exerted their agency by selecting additional modules beyond those that were required to enhance their learning.

**Creative Projects**

For a more direct measure of student learning—the blind assessment of pre and post digital projects—we again conducted a paired sample t-test on each of the 5 project competencies. There were a total of 65 students with matched pre and post projects available for assessment. Figure 5 shows highly significant improvements for all 5 of the competency areas. Again, while it may not be surprising to see improvements over the course of a semester-long class, the comprehensive gains on these fairly general and potentially transferable skill areas indicates a potent overall learning effect in this important domain of digital media design.

![Average Student Project Ratings on 5 Competencies](image)

*Figure 5. Comparison of average ratings of pre and post digital projects on 5 competency dimensions*

**Implications and Future Applications**

The data collected in this study support the notion that designing online instruction with explicit elements of narrative and student agency aids student learning and strengthens their engagement in the course. This is evident at the most basic level by strong student enthusiasm for additional course features that support these elements, such as the story animations and the ability to choose their learning modules. Student comments collected at the completion of the course also indicate a highly positive response, such as the following remarks from one student:

“What I liked most about the course was the vast amounts of topics to learn from—the ability to choose what you learn from and do assignments on what you know or would like to get better at.”

Evidence for positive effects on student learning came from various sources such as student reports of higher levels of critical thinking compared to other online courses, reports of improved skills in the target domain, and increased ratings of design and development skills pre to post on the students’ original digital media creations. Comparisons with other courses should be interpreted with caution given the inherent differences in instruction and course content, however, a great deal of effort was made to select comparison courses that were also surveys of interesting topics and with instructors that had a reputation for strong online teaching. Taken together, results described here demonstrate that the explicit integration of narrative and consideration of student agency can have a positive impact on online instruction.
From a theoretical perspective, these findings suggest that narrative and agency have complementary influences on processes of learning and engagement, and it lends support to the vision of interactive digital environments as nurturing human thinking and creative expression (Murray, 1997). The current study design does not allow for a precise explication of the interaction between narrative and agency, however. Additional research is needed to determine whether, for example, a strong narrative has the potential to overshadow the effects of individual choices or make people feel that these choices are less of their own. More research on narrative and agency individually is also needed, such as identifying the specific elements of narrative (e.g., plot, character, or environment) or the kinds of stories that are best suited for particular types of learning. Likewise, there are additional questions about agency that could be asked such as how consequential the choices students are given need to be. For example, should students be allowed to make decisions that could put them on a sub-optimal path or even failure?

As they pertain specifically to online learning, the findings of this study offer more general support to the idea that online instruction designs should try to leverage the psychological affordances of remote and personalized learning platforms, rather than attempting to replicate traditional classroom practices. Agency and narrative are both key elements in the practice of interactive digital storytelling which has been shown to have benefits for learning for a range of age groups and educational contexts (e.g., Bers & Cassell, 1998). We hope that this work will encourage more attempts at creatively implementing interactive storytelling practices into online instruction.

In future research we will be investigating whether these engagement and learning effects can be enhanced further through additional interactive features. Specifically, we intend to look at whether the highly effective reward and incentive features of contemporary gaming systems and virtual worlds (Castronova, 2006) can be integrated into an online university course. The prevalence of online instruction will only continue to spread across all forms of education. It is important that we continue to push forward with designs that leverage both the unique affordances of contemporary media technologies and established principles of human learning and cognition.

Acknowledgements

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References


An Investigation of Teaching and Learning Interaction Factors for the Use of the Interactive Whiteboard Technology

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*Corresponding author

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ABSTRACT

Researchers who have examined the use of interactive whiteboards (IWBs) for pedagogic uses have often suggested that IWBs would likely affect both teachers’ teaching and students’ learning styles. This article defines four IWB supported teaching and learning interaction factors: IWB Supported Teaching (IST), IWB Supported Learning (ISL), Teacher Supported Learning (TSL), and Student Interactive Learning (SIL). A quantitative analysis of classroom observation records (683 instructional events) was conducted using descriptive statistics and a chi-square test to uncover the association between interaction factors. The results show that these four interaction factors were significantly associated with each other, and over 90% of the instructional events examined simultaneously complied with IST and TSL behaviors. Finally, this study may be of importance to explain the dynamic association between interaction factors and to provide a novel approach for educators to gain insight into how teaching and learning interaction about IWB technology relates to their usage.

Keywords

Interactive whiteboard technology, Improving classroom teaching, Pedagogy issues, Evaluation methodology

Introduction

In January 2002, the Welsh Assembly Government in the United Kingdom announced that it would provide every primary school with one interactive whiteboard (IWB), one computer, and one projector while every secondary school would receive three of each. In the meantime, pilot studies in England resulted in the ‘Schools Interactive Whiteboard Expansion Initiative 2003-04’ in September 2003. These moves made the IWB a particularly important focus for educational debate and research (Beauchamp, 2004). Subsequently, in April 2009, the Taiwanese government approved a budget of NT$3.9 billion (about US$12.4 million) to invest in better-designed classrooms and e-teaching equipment in elementary schools as well as to fund Internet access upgrades. These classrooms were set for installation with different facilities, each according to the subject taught. IWB was one technology under consideration (Ministry of Education, 2009).

IWBs have become significant platforms for learning interaction between teachers and students. Such devices not only replace traditional blackboards but also enable users to integrate and manipulate visual multimedia resources. A growing numbers of studies (Armstrong et al., 2005; Bruun, 2009; Glover & Miller, 2001; Jankowska & Atlay, 2008; Kennewell & Morgan, 2003; López, 2010; Schmid, 2008; Smith, Hardman & Higgins, 2006) have focused on curricula, pedagogy, and the process of utilizing IWBs in schools. For example, in a traditional classroom, teachers allow students to use the blackboard for demonstration purposes. Classroom demonstrations can now be integrated with IWB functions and enable students to move the material, accomplish tasks, and mark annotations as needed. These capabilities can improve the demonstration activity and reveal students’ developmental progress, thus affecting the teaching and learning interaction in the classroom (Glover, Miller, Averis & Door, 2005).

Although these IWB related studies focus on the relationship between technology and interactive pedagogical practices in the classroom. Little attention has been paid to relevant associations among teaching, learning and IWBs. Research is especially needed to examine how teachers actually use IWBs and how this use could be strengthened (Torff & Tirota, 2010). Moreover, there are no specific demonstrations of teaching and learning interactions in the literature, and almost all of the relevant studies take place in a Western, rather than an Asian context. These are the gaps in the research that the current study seeks to address.
This study develops a method of analysis that provides richer insights into technology-mediated teaching and learning interactions and then investigates the associations among IWBs and teaching and learning interactions.

Teaching and learning interactions with regard to IWBs

Interactions between teachers and students are not always in consensus reciprocally but are instead a process of confrontation and negotiation. In the interaction process, both teachers and students utilize various strategies in an attempt to confirm their own ideas. These strategies usually result in a well-ordered interaction model and the development of a common consensus. For example, the way a teacher provides information to a student is dependent on his or her perception of the student’s cognitive abilities. This perception is directly influenced by the prior interactions between the teacher and student (LeBlanc & Bearison, 2004). On the other hand, the interaction between teachers’ perceptions of Information and Communication Technology (ICT) and pedagogy is also important. Loveless (2003) highlighted the teacher’s perceptions of ICT as a social and cultural phenomenon that requires more investigation.

After the IWB was first introduced into the classroom, it obviously influenced the interaction between the teacher and his or her students, which initiated the interaction reform in the classroom (Glover et al., 2005). Moreover, Anderson (2003) emphasized that rapid advances in information technology would make interaction transmission simpler and faster and that this should be adapted accordingly to conform to contemporary education. Keegan (1988) also noted that interaction is a key factor in information transmission and effective learning.

Moore (1989) divided distance education interaction into three types: student-content (learning material) interaction, student-student interaction, and student-teacher interaction. Expanding upon Moore’s interaction types, Anderson and Garrison (1998) proposed three additional kinds: teacher-teacher interaction, teacher-content interaction, and content-content interaction. To investigate how the IWB-supported teaching and learning interaction occurs, this study adopted both interaction structures. Because the classroom setting has only one teacher and one IWB, we refer to the IWB, teacher, and students in three dyadic interactions without considering the IWB-IWB interaction and the teacher-teacher interaction. This adoption is similar to the Kennewell and Beauchamp (2007) study that looked for evidence concerning effects of the IWB on learning-related activities (Kennewell & Beauchamp, 2007, p. 229) that included learner-IWB, teacher-IWB, learner-teacher, and learner-learner interaction through the IWB. Figure 1 depicts the four IWB supported teaching and learning interaction factors proposed in this study: IWB Supported Teaching (IST), IWB Supported Learning (ISL), Teacher Supported Learning (TSL), and Student Interactive Learning (SIL).

<table>
<thead>
<tr>
<th>Interaction factor &amp; subcategory</th>
<th>Definition</th>
<th>Element of subcategory</th>
</tr>
</thead>
<tbody>
<tr>
<td>IWB supported teaching (IST)</td>
<td>Teacher utilizes IWB intuitive manipulation to integrate multimedia material and develop interactive teaching design, which assists the teacher in managing teaching activities, enhancing interaction quality, and reinforcing students’ conceptual understanding.</td>
<td>IWB interactivities</td>
</tr>
<tr>
<td>IST1: IWB facilitated teacher’s manipulation</td>
<td>All of the teacher's physical manipulation behaviors on the IWB, e.g., opening and closing files, clicking and selecting items, annotating and drawing objects.</td>
<td>Physical interactivity</td>
</tr>
<tr>
<td>IST2: IWB supported integration of Internet and multimedia resources</td>
<td>Teacher integrates and presents Internet and multimedia resources on the IWB, e.g., saving and reusing the materials, the interactive functions: drag and drop, pull and abandon, hide and reveal.</td>
<td>Technical interactivity</td>
</tr>
<tr>
<td>IST3: IWB supported interactive teaching design</td>
<td>Teacher utilizes particular features of the IWB in conceptual instruction activities, e.g., explanations, demonstrations, and discussions.</td>
<td>Conceptual interactivity</td>
</tr>
<tr>
<td>Teacher supported learning (TSL)</td>
<td>Teacher utilizes IWB in instruction that would be more efficient to reach the learning goal. The teacher’s role transforms from teacher-centered instruction into student-centered guidance and assistance.</td>
<td>Teaching roles</td>
</tr>
</tbody>
</table>

Table 1. IWB supported teaching and learning interaction factors
other words, the teacher becomes the student’s learning coach, observer, and facilitator.

<table>
<thead>
<tr>
<th>TSL1: Teacher as a coach</th>
<th>Teacher adopts the advantages of IWB supported teaching to increase the understanding and guidance of students’ conceptual development, e.g., by discussing and verifying the learning content with students.</th>
</tr>
</thead>
<tbody>
<tr>
<td>TSL2: Teacher as an observer</td>
<td>The teacher observes students proceeding with the learning activity and perceives different learning styles and individual needs. Afterward, the teacher would appropriately revise the instructional content in order to reach the adaptive learning goal.</td>
</tr>
<tr>
<td>TSL3: Teacher as a facilitator</td>
<td>The teacher designs the interactive activity and utilizes questions to stimulate discussion. In the classroom, the teacher encourages students to lead the learning progress and facilitates their undertaking of the learning task.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>IWB supported learning (ISL)</th>
<th>IWB supports students’ intuitive manipulation and allows integration with the Internet and multimedia resources by the IWB single interface. Students utilize IWB as a learning tool, and the advantage of such learning is that it simplifies the learning task and then facilitates learning efficacy.</th>
</tr>
</thead>
<tbody>
<tr>
<td>ISL1: IWB facilitated student’s manipulation</td>
<td>All of the students' physical manipulation behaviors on the IWB, e.g., opening and closing files, clicking and selecting items, annotating and drawing objects.</td>
</tr>
<tr>
<td>ISL2: IWB as a learning tool</td>
<td>Students utilize IWB as a learning tool, e.g., to accomplish or present a task, to drill and practice the learning material, and to solve problems.</td>
</tr>
<tr>
<td>ISL3: IWB increased learning efficacy</td>
<td>Students utilize IWB and benefit from increased conceptual learning efficacy, e.g., it assists the understanding, memorization, and thinking processes.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Student interactive learning (SIL)</th>
<th>Students utilize IWB and benefit from increased learning interest, motivation, and participation, which allow students to move from passive learning into active and independent learning. It also positively influences peer cooperation in the task.</th>
</tr>
</thead>
<tbody>
<tr>
<td>SIL1: Student’s learning interest</td>
<td>Students have high interest and motivation in the learning activity with IWB, which enhances student involvement in learning tasks.</td>
</tr>
<tr>
<td>SIL2: Active participation of students</td>
<td>IWB encourage students to actively participate in learning and be more focused on the tasks, e.g., actively questioning or adding to the teacher's or classmates' comments.</td>
</tr>
<tr>
<td>SIL3: Student’s peer cooperation</td>
<td>Students utilize IWB to cooperate in tasks. They could support with each other and contribute their own skills, e.g., comment on classmates’ presentations, identify mistakes when classmates demonstrate on the IWB, and help in finding correct answers.</td>
</tr>
</tbody>
</table>

**Figure 1.** IWB supported teaching and learning interaction factors
There has also been a growing body of evidence concerning the range of teaching and learning interactions (LeBlanc & Bearison, 2004; Smith et al., 2006; Kennewell & Beauchamp, 2007; Slay et al., 2008; Torff & Tirotta, 2010; Warwick et al., 2010). For the sake of simplicity, we combined these dimensions to focus our attention on the nature and purpose of the four interaction factors. We then subdivided each interaction factor into three subcategories according to existing classroom pedagogy literature and examined these systematically to select for earlier studies that categorized various interactions. The various elements of the subcategories of the interaction factors are listed in Table 1. The first and second columns present the classifications and definitions of the four IWB supported teaching and learning interaction factors and 12 subcategories, which were proposed by this study based on a review of the literature. The third column indicates the element that was used to structure each subcategory’s definition. In this study, we also adopted Table 1’s definition in the coding procedure.

**Research context and methodology**

In order to verify the IWB supported teaching and learning interaction factors revealed earlier in this paper and to consider how these factors are related between teachers and students during activities, we conducted a case study in an IWB-based learning environment. The analyses of the interaction factors were used to examine the support and lack of teaching and learning interactions with regard to the use of IWB.

**Research procedure**

This study involved three phases. First, it generalized the IWB supported teaching and learning interaction factors from an analysis and discussion of the relevant literature. These factors were used as the classification categories and observation variables for this study. Secondly, in order to conduct a case study, we constructed an ICT learning environment based on IWB, and then we embarked on a case study of one teacher and 29 students using the IWB in a Mandarin course. Furthermore, to explain the teaching and learning interaction, we utilized a quantitative analysis method to code the classroom observation data to examine the relationships among the factors. Finally, the research verified the support and lack of teaching and learning interactions in an IWB-based learning environment based on this data.

**Case study: classroom observation**

We conducted a case study to examine one teacher and 29 second-grade students (males=17, females=12) using an IWB (Hardware: Promethean ActivBoard PRM-AB2-06, Software: Promethean ActivPrimary V2) in the classroom. The teacher had already acquired more than six years of ICT instructional experience, and she owned the Level 1 certification that Promethean identified. All students had one and a half years ICT learning experience with the teacher. All participants had utilized IWB for only half a year before the experiment.

**Figure 2. A sample of instructional event analysis**

We used a digital camcorder to record the process of the teacher using the IWB to teach five Mandarin teaching units for about two months. For each unit, generally accomplished in five lessons, the teacher firstly taught the words, phrases, and abstract of the article, and then she discussed the topics with the students according to the unit. A total of 25 lessons (about 16 hours) of video material were collected. Afterward, this study adopted one minute as the analytic unit for one instructional event. Meanwhile, we asked the teacher to give a brief description of every
instructional event (the upper part of Figure 2) and eliminated those events (e.g., working on assignments, classroom management) that were not classified as IWB instructional events. The total instructional events (n=683) were then used as data to conduct the coding procedure in this study.

Before the coding procedure, four expert teachers discussed how to achieve a consensus to match the definition of the classifications (12 subcategories in Table 1), which would improve the consistency of data classification. Next, the expert teachers cooperatively reviewed and coded the behavior attributes of the 12 subcategories between appearance (1) and disappearance (0) for each instructional event. If the coding process had any disagreement, the expert teachers would immediately discuss the event and achieve consensus on it. After the coding procedure, we summed up the results of the 12 subcategories for the four interaction factors. The set of interaction factor results might be (0, 1, 2, 3), which was expressed as a nominal scale for each interactional factor. For example, as shown in the lower part of Figure 2, IST=IST1+IST2+IST3=0+1+0=1 (pattern 010 in scale 1), TSL=TSL1+TSL2+TSL3=1+1+1=3 (pattern 111 in scale 3). This measure was designed to differentiate the quantity of interaction factor strength, reflecting on the interaction pattern of the teaching and learning behavior for every instructional event.

Subsequently, we considered the analysis results of all instructional events as the observed data of IWB influencing teaching and learning interaction. Then, we performed a chi-square test for independence in examining the associations among factors. Although the test needs to avoid very small hypothetical frequencies (Cohen, 1988, p. 216), as a general rule, other researchers’ recommendations with respect to the minimum expected cell frequencies have included recommended minimum values of 1, 5, 10, and 20. However, the chi-square statistic may be properly used in cases where the expected values are much lower than previously considered (Delucchi, 1983). Moreover, even the occurrence of expected values below 1 generally does not invalidate the procedure.

Results

The analysis results of the instructional event

We calculated the analysis results of the instructional events (n=683), which were examined and coded by the expert teachers. Figure 3 shows the descriptive statistic result of 12 subcategories and Table 2 presents the result of the subcategory patterns in a joint distribution of the interaction scales within four interaction factors. For example, in all IST1 data, 500 instructional events were coded 1 and all were located in scale 3 (pattern 111, as shown in Table 2, scale 3 row cross IST column), accounting for 73.21% of the total, as shown in Figure 3’s IST1’s percentage. For IST2, 629 instructional events were coded 1, including 86 events in scale 1 (pattern 010), 43 events in scale 2 (pattern 011), and 500 events in scale 3 (pattern 111), accounting for 92.09% of the total, as IST2 percentage shown in Figure 3.
In general, the results show that IST and TSL were two main factors that dominated over ISL and SIL in this study. With regard to the IST, as Table 2 shows, the count of scale 3 (pattern 111) was the highest. This means the most of the instructional events are within the behavior of IWB supported teaching. Among TSL’s subcategories, the total events were coded in TSL1 and it was the highest subcategory, TSL3 was second and TSL2 was the lowest. This indicates that the teacher supported student learning mainly as a coach role.

In contrast with IST, the events coded in ISL were relatively low, the highest subcategory was ISL3, in which the events were almost all clustered in scale 1 (pattern 001). The behaviors of ISL1 and ISL2 appeared very rarely. Therefore, the IWB supported student learning was largely increasing the learning efficacy. Among SIL’s subcategories, the behaviors of SIL1 and SIL2 were almost all clustered in scale 2 (pattern 110), and the behaviors of SIL3 were relatively few. Therefore, the student learning interactions were mainly presented with regard to increased learning interest and active participation behaviors. The peer cooperation behaviors among students were very rare.

Table 2. The descriptive statistics of the results of the instructional events analysis in a joint distribution of scales and factors

<table>
<thead>
<tr>
<th>Interaction scales</th>
<th>Subcategory patterns</th>
<th>IST</th>
<th>TSL</th>
<th>ISL</th>
<th>SIL</th>
<th>Scale marginal</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0 0 0</td>
<td>52</td>
<td>14</td>
<td>363</td>
<td>340</td>
<td>769</td>
</tr>
<tr>
<td></td>
<td>Count</td>
<td>52</td>
<td>14</td>
<td>363</td>
<td>340</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Column %</td>
<td>7.61%</td>
<td>2.05%</td>
<td>53.15%</td>
<td>49.78%</td>
<td>28.15%</td>
</tr>
<tr>
<td></td>
<td>Row %</td>
<td>6.76%</td>
<td>1.82%</td>
<td>47.20%</td>
<td>44.21%</td>
<td>100.00%</td>
</tr>
<tr>
<td>1</td>
<td>1 0 0</td>
<td>0</td>
<td>252</td>
<td>0</td>
<td>29</td>
<td></td>
</tr>
<tr>
<td></td>
<td>0 1 0</td>
<td>86</td>
<td>99</td>
<td>0</td>
<td>43</td>
<td></td>
</tr>
<tr>
<td></td>
<td>0 0 1</td>
<td>2</td>
<td>36</td>
<td>298</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Count</td>
<td>88</td>
<td>387</td>
<td>298</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Column %</td>
<td>12.88%</td>
<td>56.66%</td>
<td>43.63%</td>
<td>10.54%</td>
<td>30.9%</td>
</tr>
<tr>
<td></td>
<td>Row %</td>
<td>10.41%</td>
<td>45.80%</td>
<td>35.27%</td>
<td>8.52%</td>
<td>100.00%</td>
</tr>
<tr>
<td>2</td>
<td>1 1 0</td>
<td>0</td>
<td>66</td>
<td>1</td>
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</table>

Note.

a The first column represents the interaction scale set (0, 1, 2, and 3) of this study.

b The second column represents the results of the subcategory coded composition, with item ***1 representing IST1/TSL1/ISL1/SIL1. For example, the composition of the 000 pattern means ***1+***2+***3=0+0+0=0 was classified to scale 0; the 010 pattern means ***1+***2+***3=0+1+0=1 was classified to scale 1. The other columns represent the coded results’ calculation with regard to the four interaction factors.

The associations between the interaction factors

This study performed a chi-square test for independence in analyzing the associations between the factors and the joint distribution of scales results are shown in Table 3. All six paired factors’ associations were significant at the .001 level that support the nature of interactions between teachers and students are reciprocal.
Table 3. The results of the chi-square test for independence between IWB supported teaching and learning interaction factors

(a) IST * TSL

<table>
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<tr>
<td>% of Total</td>
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</tr>
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<tr>
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<td>Total</td>
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<tr>
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(b) IST * SIL

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(c) IST * IL

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(1) IST versus TSL

The results of the chi-square test ($\chi^2=60.667, p<.001, w=.298$; the $w$ represents the effect size index that means the degree of association between factors) show that IST was significantly associated with TSL. As displayed in Table 3a, there were 90.34% (total events exclusive IST=0 or TSL=0, $n=683-52-14+0=617$) of instructional events that simultaneously complied with IST and TSL behaviors. According to the TSL instructional event results (as Figure 3 shows), we found that TSL1 behaviors were more common than TSL2 and TSL3, meaning that the teacher mainly utilized IWB to support teaching, and that this was associated with a coach role.
(2) IST versus ISL

IST was significantly associated with ISL according to the results of the chi-square test ($\chi^2=123.970$, $p<.001$, $w=.426$). A total of 46.85% (as Table 3b shows, $n=683-52-363+52=320$) instructional events simultaneously complied with IST and ISL behaviors. Moreover, according to the results in Table 2, the ISL results that were coded in scale 1 all complied with ISL3 (pattern 001, $n=298$, 43.63%), which means that the teacher mainly utilized IWB to support teaching, and it was associated with IWB as benefiting the learning process. However, as Table 3b shows, there were 31.19% (scale 3) and 10.10% (scale 1) of IST events that were corresponding to ISL events of scale 0, which indicates some circumstances of the teacher using IWB to support teaching, but there were no IWB supported student learning behaviors.

(3) IST versus SIL

The chi-square test results ($\chi^2=78.118$, $p<.001$, $w=.338$) show that IST was significantly associated with SIL. There were 50.22% (as Table 3c shows, $n=683-52-340+52=343$) instructional events that simultaneously complied with IST and SIL behaviors. Furthermore, according to the Table 2 results, we found SIL results coded in scales 1 and 2 almost all complied with SIL1 (as Table 2 shows, $n=\text{pattern } 100+\text{pattern } 110=29+241=270$, 39.53%) and SIL2 (as Table 2 shows, $n=\text{pattern } 010+\text{pattern } 110=43+241=284$, 41.58%). This means that the teacher mainly utilized IWB to support teaching, and this might be associated with students’ increased learning interest and active participation. However, as Table 3c shows, over 32.65% of IST events corresponded to SIL events of scale 0, which indicates some circumstances of the teacher utilizing IWB to support teaching, and there were no student interactive learning behaviors.

(4) TSL versus ISL

The relatively lowest degree of association between the two factors was detected by the following the chi-square test result ($\chi^2=51.734$, $p<.001$, $w=.275$). There were 46.41% (as Table 3d shows, $n=683-14-363+11=317$) of instructional events that simultaneously complied with TSL and ISL behaviors. As described earlier, we found that ISL events coded in scale 1 all complied with ISL3, and according to the results in Table 2, the TSL instructional events coded in scales 1 and 2 almost comprised TSL1 (as shown in Table 2, TSL column, $n=\text{pattern } 100+\text{pattern } 110+\text{pattern } 101=252+66+175=493$, 72.18%). Thus, the teacher supported students’ learning, especially in a coach role, and might be associated with increased student learning efficacy. However, over half (as Table 3d shows, calculated TSL exclusive TSL=0 while ISL=0, $n=363-11=352$, 51.54%) of the TSL events corresponded to ISL events of scale 0, which indicates some circumstances of the teacher in a coach role. There were no IWB-supported student learning behaviors. These results were similar to those of the association between IST and ISL. However, the degree of association between IST and ISL was higher than that of TSL and ISL, which shows that the IST had a stronger degree of association with ISL (Cohen, 1988, p. 221).

(5) TSL versus SIL

Analyzing the scale of interaction between TSL and SIL, we found significant associations according to the chi-square test result ($\chi^2=195.779$, $p<.001$, $w=.535$). There were 50.22% (as Table 3e shows, $n=683-14-340+14=343$) of instructional events that simultaneously complied with TSL and SIL behaviors. As described earlier, we found that the SIL events coded in scale 2 almost all complied with SIL1 and SIL2, and TSL instructional events coded in scales 1 and 2 almost all complied with TSL1. Thus, that the teacher supported students’ learning, especially in a coach role, might be associated with increased student learning interest and active participation, although in some circumstances no students’ interactive behaviors were found. These results were similar to those for the association between IST and SIL. However, the degree of association between IST and SIL was lower than that of TSL and SIL, which means the TSL had a stronger degree of association with SIL.

(6) ISL versus SIL

The outcome of the chi-square test ($\chi^2=274.203$, $p<.001$, $w=.634$) found the strongest degree of association between the two factors. There were 28.40% (as Table 3f shows, $n=683-363-340+214=194$) of instructional events that...
simultaneously complied with ISL and SIL behaviors. As described earlier, we found that the ISL events coded in scale 1 all complied with ISL3, and the SIL events coded in scale 2 almost all complied with SIL1 and SIL2. Thus, students presented learning interest and active participation in these circumstances, and the use of IWB simultaneously increased their learning efficacy. However, a total of 31.33% instructional events turned out no SIL events (scale 0) with corresponding ISL events in scale 0, which indicates some circumstances are without any IWB supported learning or student interactive learning behaviors.

Discussion

Teacher’s teaching

According to the analysis of the instructional events, there were over 70% instructional events that had both IST and TSL behaviors simultaneously and nearly a medium degree of association between IST and TSL. Hennessy et al. (2007, p. 291) revealed that whole-class teaching was the predominant mode of IWB use, with the teacher and students focusing on the board for an average of 72% of the lesson time. This was similar to the results of this study. We found that the teacher played mainly a coach role and extensively used IWB supported intuitive manipulation, integrated the Internet and multimedia resources, and conducted the interactive teaching design. Use of the IWB increased the interaction quality of teaching, helping the teacher to guide student learning. With regard to teacher-supported learning with ICT, teachers differ in the degree to which they act as coaches, observers, and facilitators of learning, and thus differences may occur in stimulating students’ knowledge construction. These pedagogic changes would influence the whole-class and group activities, even the use of the textbook. The observations show the teacher adopted this new technology to guide students’ conceptual learning. However, the premise for well-constructed IWB integration into instruction is that the teacher would then tailor lesson plans to maximize the use of these techniques, and not simply use the IWB for illustrative purposes (Glover et al., 2005).

Student’s learning

Compared to a teacher’s instruction, we found about 30% instructional events that were without both ISL and SIL behaviors. Moreover, we found another 35% of instructional events without ISL or SIL behaviors and only less than 20% in which the students revealed learning interest, active participation, and simultaneously increased learning efficacy by using the IWB. This result might be due to the fact that the classes observed in this study did not include the extracurricular learning activities. Therefore, we suggest that future studies include observations of student self-learning situations to better understand the effects of teaching and learning interaction associated with IWB.

Dhindsa and Emran (2006) suggested that the teacher should allow students to learn collaboratively in order to acquire, construct and reorganize their knowledge. Obviously, in this study, the student peer cooperation (SIL3) was unusual in the classroom. Thus, the teacher should consider how to change the pedagogic strategy in order to meet the students’ learning needs. For example, in Wall et al.’s study (2005), the students made major comments on how the visual and verbal elements complemented each other and promoted effective learning. This tendency illustrated how the students felt about the IWB supporting their thinking and learning. Glover et al. (2005) pointed out that when teachers perceive the potential of IWB to affect interaction between themselves and their students, they need pedagogic change, especially in regard to integrating technology and media into instructional design and using more interactive approaches.

Teaching and learning interaction

While there were over 90% instructional events that simultaneously comprised both IST and TSL behaviors in regard to teaching and learning interaction, the results of IST and TSL as compared to ISL and SIL showed that only about half of the instructional events revealed teacher’s instruction associated with student learning behaviors. This meant that about 40% of teaching behaviors were not associated with student learning behaviors. In total, at least 30% instructional events were observed without both ISL and SIL behaviors, especially in regard to learning with high interest (SIL1), active participation (SIL2), and IWB increased learning efficacy (ISL3). To further investigate these phenomena, we reviewed and compared the IST and TSL instructional events with the ISL and SIL results. In IST’s
instructional events, the results showed that the instructional types occurred when the teacher lectured the students while presenting content on the IWB. In TSL’s instructional events, the teacher was orally guiding student discussions or presentations. For example, while the teacher was showing or explaining the content, the student was watching, listening, reading, or rehearsing. This supports the findings of Glover and Miller (2001), who indicated that improved presentation was the most frequent advantage of IWB, which might strengthen teacher-centred learning and cause the above results without ISL and SIL behaviors. As Hennessy et al. (2007) revealed the problem may be that students have few opportunities to manipulate IWB.

Furthermore, Wood and Ashfield (2008) pointed out that teachers use IWB to strengthen multimedia teaching and learning, which also benefits teacher supported student learning through whole-class teaching. However, teachers who misapply IWB technology and overuse multimedia would lead to “overwhelming” or “spoon-feeding”, which might cause cognitive overload (Schmid, 2008). Over-lengthy use of IWB as a presentation medium with student interaction can lead to boredom and subsequent disruptive behaviors (Thompson & Flecknnoe, 2003). Whether this is another reason for the lack of student learning interaction should be further studied. Armstrong et al. (2005) noted that teachers are critical agents in mediating the software into the subject aims of the lesson and in ensuring the appropriate use of the IWB to promote quality interactions. Training and ongoing support is thus required for teachers to appropriately use IWB technology.

In this study, the teacher had only half a year experience with IWB usage and was still preparing to integrate the technology into her instructions, and she might require more time to better utilize it. Furthermore, the teacher should make more of an effort regarding interactive learning design and work to enhance IWB-supported student learning, particularly in regard to stimulating student interactive learning at the whole-class, individual, and group interaction levels. Just as Dhindsa and Emran (2006) noted, the technology does not have a critical influence on students, and the more important thing is that the teacher constructs an environment to enable students’ active, cooperative, and responsible learning. For example, Jankowska and Atlay (2008) designed a ‘creative learning space’ improving students’ engagement and enhancing them becoming more active learning. As our studies (Huang, Chiu, Liu & Chen, 2011; Huang, Huang, Huang & Lin, in press; Huang & Wu, 2011; Lin, Lin & Huang, 2011; Lin, Huang & Cheng, 2010) built the environments for composing collaborative learning groups and u-learning. In these environments, concept development occurs through the learners’ observation, response, and interaction processes, which enhances knowledge construction (Glover et al., 2005).

Conclusion

This study investigated the teaching and learning interaction factors pertaining to IWB technology. We defined the IWB supported teaching and learning interaction factors in order to investigate and analyze the teacher and student interaction in classroom activities. Furthermore, we explored the association between teaching and learning interactions in an IWB-based learning environment.

We found that, as a novice user of IWB, the teacher integrated abundant multimedia and interactive design in learning activities, which improved the presentation quality and quantity in teaching and enabled the teacher to be more confident and have more time to guide the students’ learning. Such learning activities stimulated the students’ interest and active participation, and enhanced the interaction between the teacher and students (Glover & Miller, 2001; Glover et al., 2005) so that the latter could more efficiently reach the learning goal. These findings are in line with previous studies, although no previous study has asked this question in detail. Additionally, the previous studies all used very different measures to study the use of IWB for pedagogic purposes.

We can conclude with certainty that the integration of IWB in the teacher’s instruction did indeed enhance the instructional presentation. However, the results also revealed the lack of IWB supported student learning and student interactive learning behaviors during classroom activities. This should further be examined as to whether the teacher’s instructional strategy misapplied resources or other issues. This also raised another question: how does one measure whether the teacher’s IST or TSL is adapted to students? Just as in earlier research, the pedagogy, instructional strategy and course plans should be reformed; otherwise, the benefit of interactive technology cannot be obtained, and it may even have negative impacts in class.
Finally, several pedagogical implications can be drawn from this study. The four learning interaction factors and analytic method adopted in this study can be used to further investigate the association between teaching and learning interactions when using IWB. In future work, more empirical studies of different curricula and participants would contribute to a better understanding of the interaction between the teacher and students when using the IWB interactive technology.

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References


A Project-based Digital Storytelling Approach for Improving Students’ Learning Motivation, Problem-Solving Competence and Learning Achievement

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ABSTRACT

Although project-based learning is a well-known and widely used instructional strategy, it remains a challenging issue to effectively apply this approach to practical settings for improving the learning performance of students. In this study, a project-based digital storytelling approach is proposed to cope with this problem. With a quasi-experiment, the proposed approach has been applied to a learning activity of a science course in an elementary school. A total of 117 Grade 5 students in an elementary school in southern Taiwan were assigned to an experimental group (N = 60) and a control group (N = 57) to compare the performance of the approach with that of conventional project-based learning. A web-based information-searching system, Meta-Analyzer, was used to enable the students to collect data on the Internet based on the questions raised by the teachers, and Microsoft’s Photo Story was used to help the experimental group develop movies for storytelling based on the collected data. Moreover, several measuring tools, including the science learning motivation scale, the problem-solving competence scale and the science achievement test, were used to collect feedback as well as evaluate the learning performance of the students. The experimental results show that the project-based learning with digital storytelling could effectively enhance the students’ science learning motivation, problem-solving competence, and learning achievement.

Keywords

Project-based learning, Elementary education, Digital storytelling, Learning motivation, Problem-solving competence

Introduction

With the popularity of information technology and the rapid development of global knowledge, scholars and academia have started to pay more attention to technological instruction. Researchers have tried to develop various computerized systems or guiding strategies to assist students in improving their learning performance (Hsieh et al., 2011; Hwang, 2003; Panjaburee, Hwang, Triampo, & Shih, 2010). Chu, Tse, and Chow (2011) have indicated that effective instruction is required to cultivate the key competences of students; particularly, technological instruction which promotes student-centered learning presents a great difference from traditional direct instruction. Many scholars consider Project-Based Learning (PBL) as an excellent form of instruction to encourage the self-learning of students (Chang & Lee, 2010; Gerber, Cavallo, & Marek, 2001; Glover, 1993; Green, 1998; Moursund, 1999; Scott, 1994). David (2008) mentioned that project-based learning could provide students with more learning chances and interpersonal interactions, as it conforms to the requirements of technological instruction. Barrows (1996) indicated that students should look for more efficient learning methods based on their background knowledge and skills, and project-based learning, as a favorable learning strategy, could guide students to the application of knowledge and problem solving. Schmeck and Lockhart (1983) considered learning strategies as the methods applied in the learning process to assist learners in acquiring, managing, and integrating knowledge, as well as solving problems independently. It can be seen that project-based learning is such an approach that situates learners with higher order cognitive processes in the modified version of Bloom’s taxonomy of educational objectives, such as “analyze”, “evaluate” and “create” (Anderson, Krathwohl, Airasian, Cruickshank, Mayer, Pintrich, et al., 2001; Bloom et al., 1956).

Shih, Chuang and Hwang (2010) further revealed that project-based learning could be a student-centered learning model to promote the learning achievement of students. Moreover, Mayer (1987) considered that learning strategies
should be developed along with the students’ increase in age, and that the optimal timing to develop learning strategies is with upper elementary school classes; that is, project-based learning is suitable for being applied to the learning strategies of these upper elementary classes. Nevertheless, researchers have pointed out several problems encountered while applying the project-based learning approach in large classrooms, including the difficulties in promoting students' learning motivation, having students concentrate on the learning tasks, helping the students connect the new content with their prior knowledge, and conducting the cooperative learning activities efficiently (Blumenfeld, Soloway, Marx, Krajcik, Guzdial, & Palincsar, 1991; Gülbahar & Tinmaz, 2006; Marx, Blumenfeld, Krajcik, & Soloway, 1997; Lee & Tsai, 2004).

The advancement and popularity of computer and network technologies have resolved part of the problems. A technology-integrated PBL environment provides a real-world, constructivist, cooperative learning environment that has many advantages over the traditional PBL environment (Bottino & Robotti, 2007); that is, the difficulty in conducting the cooperative learning activities has been resolved. However, it remains a challenge to promote students' motivation and concentration on the learning tasks; moreover, it is also important to provide a way to guide the students to organize their knowledge. Therefore, the development of an effective instructional strategy for conducting project-based learning activities has become an important and challenging issue (Woods, 2010).

Scholars have identified that storytelling is an effective instructional strategy for promoting learning motivations and improving the learning performance of students (Schank, 1990). It can enhance memory by allowing learners to recall the prerequisite learning and help develop interaction among students (Bruner, 1996; Zull, 2002). Bran (2010) suggested that digital storytelling with a combination of images, sound, and texts could attract the students’ interest and enhance their learning achievement. Clark, Hosticka, Schriver, and Bedell (2002) emphasized that instruction, as the key to promoting learning achievement, should be combined with the curriculum and developed with the cognition of students in mind in order to achieve the teaching objectives.

This study aims to propose a project-based digital storytelling approach, which combines project-based learning and digital storytelling strategies to conduct learning activities for elementary school students. Moreover, an experiment has been conducted to verify the effects of the proposed approach on enhancing the learning motivation, problem-solving competence, and learning achievement of the students. The research questions investigated in this study are listed as follows:
1. Will the project-based digital storytelling improve the students’ learning motivation in science courses?
2. Will the project-based digital storytelling improve the students’ problem-solving competence?
3. Will the project-based digital storytelling improve the students’ learning achievement in science courses?
4. Will different genders have different learning outcomes with the project-based digital storytelling approach?

**Literature Review**

**Project-based learning**

Researchers have stated that project-based learning is an instructional strategy that, via participating in a project, appeals to students due to learning by way of problem solving, data collection, and discussion, as well as the presentation of the results as reports (Chu, Tse, & Chow, 2011; Howard, 2002; Koh, Herring, & Hew, 2010; Krajcik, Czerniak, & Berger, 1999; Polman, 2000; Wolk, 1994). Krajcik, Czerniak, and Berger (2003) considered that learners who participate in project-based learning would be encouraged to cooperate with their group members and to discuss and share opinions. Project-based learning aims to cultivate the capability of active and self-regulated learning of students who are the supporters as well as the learners in the process of interacting with teachers (Achilles & Hoover, 1996).

Project-based learning enhances the collaboration and the cooperation between group members, reinforcing learning cognition, and promoting learning achievement (Johnson, Johnson, & Holubec, 1994). Johnson and Johnson (1987) indicated that project-based cooperative learning develops trust among members so that, through face-to-face interactions, the effect of individual performance on the group is stressed and, by mutual supervision and reflection, the effect of collaborative learning is ensured. Johnson, Johnson, and Holubec (1994) proposed five elements for collaborative learning, namely active trust, face-to-face interaction, individual performance, interpersonal and group skills, and group process. These ideas originated from constructivism, and are based on the cognitive developmental
theory of Piaget (1950) and the social construction theory of Vygotsky (1978). Constructivism proposes that knowledge is actively constructed by individual minds and formed by interaction with the environment. Based on individual prior knowledge and previous experiences, new individual knowledge or new wisdom is generated by assimilation, adjustment, and organization of the environment in the process of interaction (Bodner, 1996).

To effectively conduct a project-based learning activity, it is necessary to design learning tasks that can promote the learning motivation and improve the learning achievement of the students. Brown, Collins, and Duguid (1989) considered interaction with the environment as the process of acquiring knowledge for human beings. Winn (1993) regarded knowledge as the learning content constructed in real situations, and argues that learners can actually obtain knowledge merely by participating in activities in a living situation. With actual activities involving the learning of knowledge and skills, learners could treat knowledge as a tool and further apply it (Brown & Duguid, 1993; Brown, et al., 1989). Effective learning requires learners to enter the social culture and meaningful situations so that they can actively interpret and comprehend the knowledge (McLellan, 1993). Situated cognition theory emphasizes the learning taking place in real activities during which students search for reasonable explanations of knowledge in the process of interaction to establish a complete knowledge system (Brown, et al., 1989; Hwang & Chang, 2011; Hwang, Chu, Lin, & Tsai, 2011; Lave & Wenger, 1991; McLellan, 1996). In this case, situations need to be established to guide students when designing project learning activities.

The advancement and popularity of computer and network technologies have provided a constructivist and cooperative learning environment (Bottino & Robotti, 2007). In the past decade, various studies have reported positive effects of the technology-integrated PBL environment on student achievement in science (Barab, Thomas, Dodge, & Carteaux, 2005; Barak & Dori, 2005; Barron, et al., 1998, Bottino & Robotti, 2007). Applying technology in PBL could support cooperative activities and constructivist approaches in learning. However, while conducting project-based learning activities in large classrooms, it is difficult to have the students concentrate on the learning tasks; moreover, for most students, it is challenging to connect the new content with their prior knowledge (Blumenfeld, Soloway, Marx, Krajcik, Guzdial, & Palincsar, 1991; Marx, Blumenfeld, Krajcik, & Soloway, 1997; Lee & Tsai, 2004). Gülbahar and Timmaz (2006) indicated that, without proper support, the students' cognitive load could be too high, indicating the need to develop or apply effect instructional strategies in project-based learning activities.

In the traditional approach, the teachers usually design a set of competition rules and a reward system when conducting project-based learning activities in large classrooms. Such a strategy can promote the learning motivation of the students; however, it is not helpful to the students in organizing their prior knowledge and the new learning materials. Consequently, in this study, we attempt to cope with this problem by integrating the digital storytelling strategy in the project-based learning approach.

Digital storytelling


In the past decades, storytelling has been widely applied to learning, and presents a favorable effect on knowledge construction and motivation promotion. For example, Burmark (2004) has reported that digital storytelling is an effective approach for helping students collect information, create new ideas, and organize their knowledge, which can improve the students' comprehension of the learning content. Robin (2008) has indicated that digital storytelling not only engages students in discussing the topics presented in the story, but also helps them organize their findings and conceptions in a more understandable way. Lowenthal and Dunlap (2010) developed a Community of Inquiry framework based on the digital storytelling approach to provide a way for teachers and students to communicate and share knowledge on the Internet. Gyabak and Godina (2011) employed digital storytelling as an instructional
intervention for bridging the digital divide between rural and urban elementary school students to help those who have never had the chance to experience computer technology.

From previous studies, it is found that digital storytelling has been treated as an effective approach to promoting cooperation and knowledge construction in classrooms; however, the effects of integrating digital storytelling and project-based learning on problem-solving competence and learning achievement have not been investigated. In this study, digital storytelling has been employed to develop the learning tasks as a project-based learning activity, including taking pictures with digital cameras, developing the story based on the pictures taken, producing a film based on the pictures by adding subtitles and a background, and presenting the story.

**Research Design**

In this study, a pre-test and post-test-designed quasi-experiment with non-equivalent groups was conducted. The independent variables were the different learning modes; the experimental group participated in the project-based learning with digital storytelling tasks, while the control group experienced the conventional project-based learning approach, for a period of sixteen weeks. The dependent variables were the science learning motivation scale, the problem-solving competence scale, and the science course achievement test.

**Participants**

A total of 117 Grade 5 students in an elementary school in southern Taiwan constituted the participants. With S-type placement, two classes were assigned as the experimental group, while the other two were the control group, with student numbers of 60 (males 35, females 25) and 57 (males 31, females 26), respectively. The experimental group took part in the project-based learning with digital storytelling, while the control group experienced conventional project-based learning, including project tasks and the presentation of results in groups, as well as evaluation by and feedback from teachers. The students in both the experimental group and the control group were randomly assigned to subgroups, each of which contained 5 or 6 members.

**Tools**

The science learning motivation scale, consisting of a total of 34 questions, was compiled by Chen (2007) and measured by a five-point Likert scale. In terms of reliability, the Cronbach's $\alpha$ is .93, showing the consistency of the scale.

The problem-solving competence scale, including a total of 30 questions, was compiled by Pan (2001) and is also measured using a five-point Likert scale. With regard to reliability, the Cronbach's $\alpha$ is .849, presenting the consistency of the scale.

The science achievement test was compiled based on the instructional objectives, covering 17 True-False questions, 17 multiple choice questions, and 7 gap-filling questions, worth a total of 100 marks. Four knowledgeable and experienced teachers were invited to examine and revise the contents, themes, meanings, numbers, and wording of the test corresponding to the science learning objectives.

The interviews of individual students were recorded with a digital recorder, and included the following questions: (1) Do you think such a digital storytelling approach is helpful to you in learning? Why? (2) Does such a digital storytelling approach for project-based learning change your attitude or motivate you in your learning? Why? (3) Is such a learning approach helpful to you in solving problems? Why? (4) Do you feel any difference between the new learning approach (integrating digital storytelling in project-based learning activities) and the previous learning approach (conventional project-based learning)?

The web-based information-searching system used by the students for collecting data on the Internet, Meta-Analyzer, was developed by Hwang, Tsai, Tsai and Tseng (2008), while the digital storytelling software adopted in this study was Photo Story 3, developed by Microsoft.
Learning activities

The unit of “I am the energy-saving master” was designed for the project-based learning activity. Five learning tasks, including “The factors of global warming”, “How to save energy”, “Comparing the energy consumption of household appliances”, “Energy-saving actions”, and “My house saves the most energy”, are listed in Table 1. Within the 16-week experiment, both groups had identical learning contents, except that the experimental group applied project-based learning with digital storytelling to the instruction, while the control group took part in general project-based learning.

Table 1. Learning contents of the project-based learning activity "I am the energy-saving master"

<table>
<thead>
<tr>
<th>Project-based activities</th>
<th>Questions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Task 1: The factors of global warming</td>
<td>1. Look for the factors of global warming</td>
</tr>
<tr>
<td></td>
<td>2. Share with groups</td>
</tr>
<tr>
<td>Task 2: How to save energy</td>
<td>1. Propose energy-saving tips and share with groups.</td>
</tr>
<tr>
<td></td>
<td>2. Collaboratively arrange and conclude feasible tips for energy-saving.</td>
</tr>
<tr>
<td>Task 3: Comparing the energy consumption of household appliances</td>
<td>1. Observe the brightness of bulbs with different wattages (W) and understand the meaning of W.</td>
</tr>
<tr>
<td></td>
<td>2. Examine the W of household appliances and sequence them by energy consumption, and complete digital records.</td>
</tr>
<tr>
<td>Task 4: Energy-saving actions</td>
<td>1. Discuss with the family plans to save energy and put them into practice by reminding each other.</td>
</tr>
<tr>
<td></td>
<td>2. Take pictures of energy-saving actions with digital cameras to complete the action record.</td>
</tr>
<tr>
<td>Task 5: My house saves the most energy</td>
<td>1. Edit the process into films and present the implementation of energy-saving actions.</td>
</tr>
<tr>
<td></td>
<td>2. Compare the energy receipts of the last two months with the same period in the last year.</td>
</tr>
<tr>
<td></td>
<td>3. Select and award the top three families which save the most energy.</td>
</tr>
</tbody>
</table>

Figure 1. Students carrying out the task of “The factors of global warming”
During the process of the project-based learning, each subgroup in the experimental group and the control group was required to collect data for completing the learning tasks. Figure 1 shows the students working on the task of “The factors of global warming” via collecting data on the Internet using the information-searching system developed by Hwang, Tsai, Tsai and Tseng (2008).

After the data collecting stage, the students in the experimental group needed to take photos and operate the editing system to develop the digital stories. Figure 2 shows the task of carrying out the “Energy-saving actions” at home and taking photos; following that, the photos were uploaded to the editing system to develop the digital story. Figure 3 shows the process of composing the film and presenting the developed digital stories with Photo Story 3, which is a photo presentation program for Windows. The students only needed to drag the photos onto a window, and arrange them as needed. The scheduled photos can be presented with various visualization effects (e.g., transitions, zooms and pans) as well as narration and an audio soundtrack. After everything is arranged, the scheduled materials can be exported as a movie file.

Figure 2. Students carrying out the task of energy-saving actions and working on the editing process of digital storytelling

Figure 3. Students presenting the developed digital stories

On the other hand, the students in the control group learned with the conventional project-based learning approach in their classrooms. They were asked to summarize what they had found after collecting data on the Internet. Each
subgroup in the control group needed to prepare a PowerPoint file to present their findings and conclusions about the issues raised by the teacher in turn. The teacher gave feedback to the students for each presentation.

**Experimental results**

**The effect of project-based learning with digital storytelling on science learning motivation**

Using the pre-test of science learning motivation scale as the covariance, the analysis of covariance was carried out to eliminate the effect of the pre-test on science learning motivation. Since the analysis of covariance involved the regression coefficient and regression line, a basic hypothesis of the regression coefficient in the regression line of each group being the same was presented. As the interaction between the independent variable of science learning motivation and the dependent variable, \( F = 0.85 \ (p > 0.05) \), did not achieve significance, the analysis of covariance could be carried out.

From Table 2, having eliminated the effect of the pre-test on the post-test science learning motivation scale, the variance resulting from different groups, \( F = 20.38 \ (p < 0.001) \), achieved significance, showing that the post test results would be affected by the experiment. In comparison with the experimental group, the moderated average presented as 4.10, and the moderated average compared with the control group appeared as 3.69. The score of the experimental group was obviously superior to that of the control group, showing that the project-based learning with digital storytelling could effectively enhance the science learning motivation of the students.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Group</th>
<th>N</th>
<th>Mean</th>
<th>S.D.</th>
<th>Adjusted Mean</th>
<th>Std. Error.</th>
<th>( F )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Post-test</td>
<td>Experimental group</td>
<td>60</td>
<td>4.12</td>
<td>0.64</td>
<td>4.10</td>
<td>0.062</td>
<td>20.38***</td>
</tr>
<tr>
<td></td>
<td>Control group</td>
<td>57</td>
<td>3.66</td>
<td>0.77</td>
<td>3.69</td>
<td>0.064</td>
<td></td>
</tr>
</tbody>
</table>

***\( p < 0.001 \)

**The effect of project-based learning with digital storytelling on problem-solving competence**

With the pre-test result of the problem-solving competence scale as the covariance for the analysis of covariance, the interaction between the independent variable of problem-solving competence and the covariance \( F = 1.77 \ (p > 0.05) \) did not achieve significance. The analysis of covariance could therefore be carried out.

From Table 3, having eliminated the effect of the pre-test on the post-test problem-solving competence scale, the variance resulting from different groups, \( F = 17.73 \ (p < 0.001) \), achieved significance, revealing that the post test results would be affected by the experiment. In comparison with the experimental group, the moderated average presented as 4.16, and the moderated average compared with the control group appeared as 3.77. The experimental group was obviously superior to the control group, presenting that the project-based learning with digital storytelling could effectively enhance the problem-solving competence of the students.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Group</th>
<th>N</th>
<th>Mean</th>
<th>S.D.</th>
<th>Adjusted Mean</th>
<th>Std. Error.</th>
<th>( F )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Post-test</td>
<td>Experimental group</td>
<td>60</td>
<td>4.24</td>
<td>0.68</td>
<td>4.16</td>
<td>0.06</td>
<td>17.73***</td>
</tr>
<tr>
<td></td>
<td>Control group</td>
<td>57</td>
<td>3.68</td>
<td>0.81</td>
<td>3.77</td>
<td>0.07</td>
<td></td>
</tr>
</tbody>
</table>

***\( p < 0.001 \)

**The effect of project-based learning with digital storytelling on science learning achievement**

With the pre-test result of the achievement test on science as the covariance for the analysis of covariance, the interaction between the independent variable of the science achievement test and the covariance \( F = 0.821 \ (p > 0.05) \) did not achieve significance. The analysis of covariance could therefore be carried out.
Table 4. Post test results of science learning achievement and analysis of covariance

<table>
<thead>
<tr>
<th>Variable</th>
<th>Group</th>
<th>N</th>
<th>Mean</th>
<th>S.D.</th>
<th>Adjusted Mean</th>
<th>Std. Error</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Post-test</td>
<td>Experimental</td>
<td>60</td>
<td>89.07</td>
<td>6.12</td>
<td>88.05</td>
<td>0.58</td>
<td>9.32**</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>57</td>
<td>84.42</td>
<td>6.81</td>
<td>85.49</td>
<td>0.59</td>
<td></td>
</tr>
</tbody>
</table>

**p<.01

From Table 4, having eliminated the effect of the pre-test on the science achievement post-test, the variance resulting from different groups, F=9.34 (p<0.01), achieved significance, showing that the post test results would be affected by the experiment. In comparison with the experimental group, the moderated average presented as 88.05, while the moderated average compared with the control group appeared as 85.49. The performance of the experimental group was obviously superior to that of the control group, revealing that the project-based learning with digital storytelling could effectively enhance the science learning achievement of the students.

The effect of gender on participation in the project-based learning with digital storytelling

Gender was further compared and analyzed for the effect of project-based learning with digital storytelling on science learning motivation, problem-solving competence, and science learning achievement.

From Table 5, having eliminated the effects of the pre-test on the science learning motivation post-test, problem-solving competence, and science learning achievement, the variance resulting from gender did not achieve significance. The project-based learning with digital storytelling could therefore effectively promote the science learning motivation, the problem-solving competence, and the science learning achievement of both genders.

Table 5. Post test results by gender and analysis of covariance

<table>
<thead>
<tr>
<th>Variable</th>
<th>Group</th>
<th>N</th>
<th>Mean</th>
<th>S.D.</th>
<th>Adjusted Mean</th>
<th>Std.Error</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Science learning motivation scale</td>
<td>male</td>
<td>35</td>
<td>4.19</td>
<td>.53</td>
<td>4.08</td>
<td>.08</td>
<td>.50</td>
</tr>
<tr>
<td></td>
<td>female</td>
<td>25</td>
<td>4.03</td>
<td>.77</td>
<td>4.18</td>
<td>.10</td>
<td></td>
</tr>
<tr>
<td>Problem-solving competence scale</td>
<td>male</td>
<td>35</td>
<td>4.24</td>
<td>.56</td>
<td>4.18</td>
<td>.08</td>
<td>1.44</td>
</tr>
<tr>
<td></td>
<td>female</td>
<td>25</td>
<td>4.25</td>
<td>.83</td>
<td>4.32</td>
<td>.09</td>
<td></td>
</tr>
<tr>
<td>Science achievement test</td>
<td>male</td>
<td>35</td>
<td>88.97</td>
<td>6.75</td>
<td>89.03</td>
<td>.61</td>
<td>.01</td>
</tr>
<tr>
<td></td>
<td>female</td>
<td>25</td>
<td>89.20</td>
<td>5.24</td>
<td>89.12</td>
<td>.72</td>
<td></td>
</tr>
</tbody>
</table>

Interviews with the experimental group after the project-based learning with digital storytelling

After completing the learning activities, 30 students in the experimental group were randomly selected for interview. The feedback of the students to the four interview questions can be summarized into four aspects, that is, “Enhancing achievement”, “Improving learning attitude”, “Promoting problem-solving competence” and “Providing a more interesting way of learning”.

In terms of “Enhancing achievement”, nine students mentioned the application of digital storytelling to project-based learning as giving them better achievement in learning. For example, A02 stated, “There was a real sense of achievement after completing the digital storytelling, which is like a film showing each piece of the well-organized content”; and A26 stated, “(We) used to report with PowerPoint; we now have digital storytelling to replace the dull presentations, and have become more confident.”

Regarding “Improving learning attitude”, seven students regarded the project-based learning with digital storytelling as having changed their learning attitude. For example, A01, A02, A06, and A09 revealed, “With the digital storytelling activity, (I) make more effort to learn and search for data.”

With regard to “Promoting problem-solving competence”, five interviewed students indicated promotion of their problem-solving competence in the process of digital storytelling. For instance, A02 indicated, “Digital storytelling would enhance our team cooperation, work capability, and thinking capacity”; and A30 revealed, “The results gave us achievement; we would unite our efforts to solve problems in group discussions.”
When asked about the differences between the project-based learning conducted in this study and that which they had previously experienced, it was found that the students in the experimental group shared a consistent point of view, that is, they considered the project-based learning with digital storytelling as being a "more interesting way of learning". In all, 11 students considered that such a strategy made the lessons more interesting and made them prefer the classes. One of them mentioned that he did not favor project-based learning, but his interest increased after the strategy of digital storytelling was introduced; another student indicated that “I did not like the original way of instruction; however, after participating in the instructional activities, I started to enjoy the class with digital storytelling.”

From the interview results, it is concluded that the project-based digital storytelling approach not only enhanced the students' learning achievement and problem-solving competence, but also improved their learning attitude and motivation. Such satisfactory results are due to the lead-in of the digital storytelling strategy in the project-based learning activity, which enabled the students to solve problems cooperatively in a more interesting manner.

**Discussion and Conclusions**

In this study, project-based digital storytelling was employed to develop a learning activity for an elementary school science course. Each group of students was asked to complete a digital storytelling project via taking pictures with digital cameras, developing the story based on the pictures taken, producing a film based on the pictures by adding subtitles and a background, and presenting the story. From the experimental results, it was found that this innovative approach improved the learning motivation, attitude, problem-solving capability and learning achievements of the students. Moreover, from the interviews, it was found that the students in the experimental group enjoyed the project-based learning activity and thought it helpful because of the digital storytelling aspect.

The experimental results and the feedback from the students conform to what has been indicated by researchers, namely that project-based learning can engage learners in cooperating with their group members and help them improve their learning achievement (Johnson, Johnson, & Holubec, 1994; Krajcik, Czerniak, & Berger, 2003). On the other hand, the findings also conform to what has been reported in previous studies, that the lead-in of computer technologies can promote the learning interest of students (Hwang & Chang, 2011; Shih, Chuang, & Hwang, 2010) and hence help them become involved in the learning situation (Haigh & Hardy, 2010; Lowenthal, 2009; Lowenthal & Dunlap, 2010; Reitmaier, Bidwell, & Marsden, 2010; Stacey & Hardy, 2011).

More importantly, as mentioned by Robin (2008), the students employed the digital storytelling software to organize the collected data based on the knowledge learned in the class in a more interesting and understandable way. Consequently, it is reasonable to owe the success of this project-based learning activity to the digital storytelling approach since it provides not only an interesting way for the students to present their findings, but also an opportunity for them to conduct active learning and organize their knowledge. The process of collecting, abstracting and organizing data has been recognized by researchers as being an effective way of engaging students in higher order thinking, which is helpful in fostering students' problem-solving competence (Chu, Hwang, & Tsai, 2010). Several studies concerning digital storytelling have also supported this viewpoint (Chung, 2006; Sadik, 2008). For example, Ring, Weaver and Jones (2008) conducted a learning activity that employed digital storytelling to help students organize their learning portfolios, and found that the students had actively made reflections and engaged in peer discussions.

Although the present approach seems to be effective, there are some limitations in generalizing the findings of this study. First, the findings were from an experiment on an elementary school science course; therefore, it could be difficult to generalize the findings to other courses or subjects. Moreover, the digital story software adopted in this study guided the students to produce the movies using a step-by-step procedure; consequently, more experiments are needed to investigate the effectiveness of using other software with more flexible functions. In the future, it is expected that more experiments can be conducted to further evaluate the effectiveness of this approach in other courses. In addition, it would be interesting to investigate the learning performance of the students with different cognitive styles or learning styles.
Acknowledgements

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References


Disruptive Pedagogies and Technologies in Universities

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ABSTRACT
This paper is a reaction to the increasing high cost of higher education and the resulting inaccessibility for the millions of potential learners now seeking opportunities for quality higher education opportunities. The paper examines the cost centers associated with campus-based and online education systems and then suggests that disaggregation may prove to be a cost-effective way to reduce tuition payments, while maintaining quality. The paper suggests that discount service models, now available to consumers in many industries may also be attractive in new models of higher education. The paper also briefly looks at the Open Educational Resources University initiative, a pilot, collaborative project attempting to test some of these innovations in a consortium of high quality, accredited public universities. Finally, we note both the disruptive characteristics of this model and commiserate opportunities for innovative providers of higher education.

Keywords
Open educational resources, Disruptive technologies, Online courses, Disaggregation

Introduction

In recent years, the emergence of low-cost, no frills, alternatives to many of the major service, transportation and manufacturing industries has had a major impact on different industries. No frills “economy cars” became available as early as the 1950s (Vance, 2008). No frills supermarkets and supermarket products and no frills holidays have been with us for some time. More recently we have even seen the growth of no frills prisons (Finn, 1996). One of the most well-known disaggregations has been in the airline industry, with the establishment of low cost carriers competing with established airlines. Significantly, there is also a major trend for established companies themselves to set up no frills alternatives, so as to remain competitive and retain market share across both traditional and no frills markets. Alternative lower cost services have also emerged in banking, travel agencies, accommodations, mobile telephony, stock brokering, and many others. Education has been relatively immune from such disruptive technologies perhaps because of the high cost of entrance (building campuses), the support and loyalty of alumni, government funders and the conservatism and anti-commercial culture of many academics and academic leaders (Christensen & Eyring, 2011).

The existing full-service higher education model is expensive and continues to become more so. Tuition costs for students and government subsidies to higher education institutions have continually increased above the rate of inflation in most western countries. For example, in the USA, between 1981 and 2011 the increase in inflation for all goods and services totaled 115% while increase in tuition costs during that time was 498% (Wadsworth, 2011). This increasing tuition cost has not been ignored by private sector entrepreneurs - as evidenced by the rapid growth of many for-profit postsecondary companies - notably the Apollo Group that owns the University of Phoenix, the Capella group and many others. Response, to these entrants into the postsecondary sector from traditional public and non-profit providers has normally taken the form of censure, complaint to public funders and derision of the product (Complaints Board, 2011). Nonetheless students, acting as consumers, continue to subscribe to their services.

In this paper we argue that some public and nonprofit institutions would be well advised to follow the lead of many other mainstream service providers and create or partner together to develop and offer ‘low cost or no frills services’. These providers can benefit from the shared branding and selective service provision, while serving to maintain market share, gain economies of scale on differentiated services, reduce costs to students and at the same time stimulate innovation in the traditional full-service side of the organization. The danger of course is that students will abandon the full-service offering and be attracted to the discount service, thus reducing even further the demand for, profitability and sustainability of the mainstream service. However, in other sectors the activity of low cost providers has served to induce innovation but rarely to kill off mainstream providers (for example the banking sector in many countries).
Unbundling of educational services

Provision of quality post-secondary educational services in general and especially those provided at a distance consists of a complicated set of service provision, with many complementary and sometimes integrated services. These include content development, and related instructional design services, student support services, distribution and sale of learning resources, provision of library services, support for full time research faculty and graduate students, direct instruction, tutorial support, registration services and sometimes social services such as networking opportunities or face-to-face social services. Many of these services are mirrored for on-campus students, but some, such as athletic services, social clubs, pubs and restaurants are not normally provided to online students - creating potential, but rarely passed on, cost savings to distance students. Typically, online provision is regarded as a revenue generator by campus-based institutions, created (in part) to generate surplus funds and thus subsidize full service campus operations. For example the Chronicle of Higher Education reported that online courses at the University of Southern New Hampshire posted a substantial profit margin in the 2011 fiscal year. The university plows this surplus into buildings, salaries, financial aid at the traditional campus, and online program improvements (Parry, 2011).

The multifaceted nature of the services and costs centers associated with this aggregation of function and service provide the context for the possibility of disaggregation and removal or outsourcing of selected component pieces of this complex education system. This unbundling could form the basis for the cost advantage of many online institutions.

In the next section we examine each of these services, showing existing and emergent services that could be unbundled, eliminated and/or outsourced to collaborative partnerships or to more effective private or public service providers. We are not arguing that there is as yet any single best solution for such unbundling, but rather that institutions should look both strategically and critically at all components of their development, delivery and accreditation systems and decide which should remain in-house and which are either not core business or which cannot be provided cost-effectively. We believe that such a thorough examination and re-engineering of higher education can result in cost savings for institutions, but more importantly could reduce the tuition cost barrier and thus increase access to quality educational opportunities.

Analysis of Higher Education Cost Centres

Research

We begin with the cost centre that is likely the most controversial, but also the one that has at least the second greatest (behind in some cases the cost of teaching) impact on learning cost - that of supporting research in the University. To many faculty, administrators and government funders, the most important function of the modern university and the defining feature that distinguishes the university from community colleges and other educational institutions is the production and dissemination of new knowledge by faculty through their research. While not denying or arguing against this important role, there can be little doubt that it is expensive and often encumbered with traditional rights and responsibilities of tenure, promotion, commercialization and mobility of faculty members. In the past two decades many universities have attempted to capitalize on the research endeavor and recover some of the costs of research through the establishment of commercialization services such as support for market analysis, securing of patents, promoting partnerships and providing incubator facilities. However, few universities have been successful at generating revenue from this commercialization. On the contrary, in many institutions, technology transfer offices have not even been cost recovery and have increased costs to university budgets (Chapple, Lockett, Siegel & Wright, 2005).

One of the most pervasive arguments for research propagated in the academy is the belief that good teaching is correlated with good researching. Or even the claim that unless one is doing active discipline research, one cannot be informed enough or competent to be a university teacher. There is little evidence to support this argument. In extensive meta-analyses of the relationship between research and teaching (Gibbs, 1995; Hattie & Marsh, 1996), each found that there was no or very little relationship between teaching and research excellence. Hattie and Marsh (1996) concluded that "the likelihood that research productivity actually benefits teaching is extremely small or that the two, for all practical purposes, are essentially unrelated. Productivity in research and scholarship does not seem to detract from being an effective teacher and vice versa" (p. 529).
This belief in the correlation of research and teaching productivity and excellence is now very pervasive among university faculty and administrations, yet it is not a factor that defined universities for most of their existence. The classical medieval Universities of Bologna, Paris, Oxford and Cambridge, were initially funded and controlled by students, who hired professors whom they believed had and were capable of sharing knowledge through their teaching. Later universities, were established to train professionals - notably Harvard - for training ministers of religion and Edinburgh for training medical doctors with little emphasis on faculty research. In later times, research was carried out mostly by gentlemen and amateur ‘natural philosophers’ who created a research system referred to by McNeely & Wolverton (2008) as the “Republic of Letters”. It was not until the 19th century that Wilhelm von Humboldt established German universities with an explicit aim of generating new knowledge and thus the laboratory became a fixture of university infrastructure. Thus, it is mistaken to argue that research has always been a defining feature of university life. However, it must be said that research and the costs of supporting that research is currently a major focus and rationale for public, government and in some countries corporate support of the modern university.

**Provision of the next generation of scholars**

Every institution strives to maintain and reproduce itself. In the case of the university this involves the training of the ‘next generation’ of researchers and teachers. It is arguable how well the university trains its faculty at teaching, and there is tendency for professors to be unimaginative pedagogues who ‘teach as they were taught’(Pocklington & Tupper, 2002). Nonetheless, if the university abdicated the training of replacement faculty (as is done by most of the private universities) there certainly will need to be alternative means created to undertake this important task. The failure of modern universities to disentangle teaching and research, especially as regards influence on both tenure and promotion, makes it very difficult for the University to induce, monitor and reward excellence in teaching and too often important personnel decisions are left to measurement of research productivity alone.

**Provision of Course and teaching materials**

The first generation of distance education institutions placed great emphasis on the creation of excellent teaching resources, in first print and later multi-media formats. This was in contrast (both in terms of time and money expended and resulting quality) to resources committed to classroom teaching. Typically classroom teachers, with the aid of a textbook or two and a set of informal lecture notes (now augmented by Powerpoint slides) produce individualized courseware, of variable quality and little or no editing or distribution. Both classroom and distance education courses are most often built upon the unbundled provision of a text book, created by commercial publishers and paid for, usually in addition to course fees, by the student.

The provision and widespread distribution of Open Educational Resources (OER) is beginning to disrupt both classroom and distance education models of courseware production and distribution. At present there are thousands of full post-secondary course modules available as OER online and tens of thousands of lesson modules in repositories such as the MIT-sponsored OCWC site, Rice University’s Connexions, the Saylor Foundation, MERLOT, the Washington State Open Course Library, ARIADNE in Europe, and many others (Hylen, 2007). In addition, the US Department of Labor has made $2 billion available over four years for training initiatives that must use an open access license (Department of Labor, 2011). Access to this rapidly growing font of usable learning materials has already increased the quantity and quality of informal learning. Seely (2011) notes that OER have had “the most visible impact” on individual learning however increasingly classes of students are using OER materials. The MIT OCW site alone has more than one million unique visitors a month. According to their statistics, 45% are self-learners and nearly 42% are students at other universities (MIT, 2011). These numbers do not count other OER sites or even MIT OCW mirror sites. Tufts University estimates that more than half of their visitors are independent learners (Lee, Albright, O’Leary, et al., 2008). As the quantity and quality of OER increases, they will become even more readily used by faculty. Already there is a large movement towards the use of open textbooks, primarily driven by their growing costs (US Government Accountability Office, 2005; Allen, 2010; Beshears, 2010).

**Provision of Student Services**

Most on campus and distance education institutions provide a host of services to their students. These include course and academic counseling that is designed to ensure students enroll in and succeed at courses that match their goals
and aptitudes. Testing and counseling services are designed to assist students in uncovering and dealing with personal or psychological challenges. Financial services are provided to help students budget and obtain loans, scholarships and bursaries to help them finance their education. The actual cost of these scholarships and bursaries is often covered by donations, but the solicitation for and administration of these scholarships is a cost component of student services. Finally, many campus-based organizations provide support for clubs, social and recreational activities. Recently online institutions are beginning to offer similar services using social networks (Anderson, 2004) - though we have yet to see virtual university football teams in the Rose Bowl!

**Academic teaching and/or tutoring**

The provision of direct teaching and establishment of ‘teaching presence’ (Garrison, Anderson, & Archer, 2001) is a major cost for universities and the one that has been shown to be associated with student satisfaction, learning outcomes and persistence (Martin & Mottet, 2010; Shaw, 2009). Most of us can recall the dramatic impact of at least one teacher in our time as a university student and mostly we remember the positive impacts. Although it has taken some time, there is a growing consensus amongst researchers, teachers and students that effective teaching presence can be established online (Gunter, 2007). The provision of interactive web conferencing, continuous monitoring and participation by teachers in asynchronous forums and the capacity for teachers to monitor student activity using learning analytics tools affords opportunity for very personal, attentive and interactive teaching presence. However, such high intensity teaching is expensive, time consuming for teachers and a major barrier to online teaching reported especially by new and inexperienced online teachers (Berge & Muilenburg, 2000; Shea, 2007).

**University Administration**

One of the largest complaints from academics is that university administration expenses are growing even faster than those associated directly with teaching and research. University hierarchies continue to grow with more deans, chairs, vice presidents, and a host of other roles (usually accompanied with support staff). This spending on administrative growth has outpaced the growth in expenditures for teaching since the 1930s (Bergmann, 1991). Unlike in other economic sectors, few universities have chosen (or as yet been forced by economic exigency) to flatten their organizations, merge, share services or otherwise drastically reduce administrative overhead.

**Do we need and can we afford the full bundle?**

In the remainder of this paper we suggest which of the services can be unbundled to create a model of university education provision that entails much lower costs for students – and/or potential for profit by private interests. We examine first the most expensive and most highly-valued service (to faculty at least) of the modern university - the discovery and dissemination of knowledge.

Quality research is expensive and there have been many good arguments demonstrating the positive economic and social benefit to the production and application of new knowledge. We are reluctant to suggest that research should be eliminated from the core function of the university, but do argue that it must be rationalized, strategic and focused. We are likely past the point where individual curiosity, unencumbered by social need, relevancy and cost efficiency can be the major driver of research funding in most universities. Recent developments using networks however promise considerable cost effectiveness in research that has not been realized in many disciplines (Nielsen, 2012). The interest in ‘open science’, that compels or induces researchers to make transparent and available their data and the processes by which they discover new knowledge, is the basis for increasing collaboration and reducing unnecessary competition (Mukherjee & Stern, 2009). Network connectivity and software also greatly enhances the capacity for creating new networks of researchers, sharing and archiving data, linking multidiscipline inquiry, discovery and filtering information and in other ways making research collaboration more effective and efficient.

The cost to institutional libraries for scholarly journals has resulted in a throttle on dissemination and grossly high profit margins enjoyed by commercial journal publishers (Monbiot, 2011). Open Access publishing of peer reviewed articles is growing in all disciplines and both universities and governments are taking efforts to at least encourage,
and sometimes to compel, faculty to disseminate their research results in ways that are accessible globally, at little or no cost to end users.

In 2003, one of the authors published a paper (Anderson, 2003), describing an interaction equivalency theory. By this we meant that interaction - long the most important, but costly component of any teaching system, from a student perspective, is generally of three types student-teacher, student-content and student-student (Moore, 1989). The first proposition of this theory is that “deep and meaningful formal learning is supported as long as one of the three forms of interaction (student–teacher; student–student; student–content) is at a high level. The other two may be offered at minimal levels, or even eliminated, without degrading the educational experience.” (Anderson, 2003).

In traditional print based forms of distance education, the reduced or absent student-teacher and student-student interaction is compensated by very rich student-content interaction with sophisticated learning materials. Similarly intense one-to-one tutorials with a teacher, may be sufficient for high quality learning without much peer or content interaction. The quality of such intense student-teacher interaction is exemplified by a quote attributed to James Garfield in reference to a former president of his college “the ideal college is Mark Hopkins on one end of a log and a student on the other.” Finally, intensely collaborative interaction among students as emphasized in many forms of problem-based and collaborative learning can afford much-reduced student-teacher and student-content interaction.

A clear way to reduce costs, without necessarily reducing quality then, is to reduce one or more of the these three forms of interaction. The most popular form of interaction and also the most expensive for institutions, is student-teacher interaction. The broadcast media have been (and still are) used in this way to ‘can’ teacher lectures, discussions or experiments and thus convert these interactions into student-content formats. The reduced cost and ease of creating video and podcasts as evidenced on YouTube and especially educational channels and services such as the Khan Academy, have taken this conversion from the work of studio technicians into an end-user production technology. A second way to reduce the costs of student-teacher interaction is to substitute most or all student-faculty interaction by increasing the quality and frequency of student-student interaction. Network technologies, and especially social networks, immersive environments and low cost synchronous and asynchronous text, audio and video conferencing are now bringing the technical provision and mastery of these services down to the consumer/creator level. Two of the biggest challenges of this substitution relate to student attitudes toward and learning competence with student-student interaction.

However, these two solutions are not easily implemented. Students enrolled in formal education programs have come to expect student-teacher interaction and teacher feedback. In numerous studies student-teacher interaction has been rated by students as the most important and helpful form component of the instructional package (Swan, 2001, 2002). Especially in countries where authority, and seniority carry very high cultural value, it seems unthinkable to develop education courses or systems without the real - or virtual interaction and feedback from a teacher. By analogy, passengers on airlines had come to expect a variety of free movies to be enjoyed during a flight. However, recent policy changes from some discount airlines, that include charging for movies, show that the number of passengers willing to pay for such service is much lower, than those who watch or profess their value when they are provided free of charge.

In addition decades of research has shown the value of student-student collaborative learning in terms of increased learning in addition to the development of communication skills, improved attitudes towards formal learning and increased time on task and persistence (Gokhale, 1995; Johnson & Johnson, 1996). Yet many students and in particular many of those who are attracted to online learning, are not comfortable with or even interested in engaging in intense student-student interaction. A number of studies have identified issues of fear of freeloeading, difficulty in project management and different expectations of effort and reward as creating challenges to effective group work (Swaray, 2011). Both of these factors need to be addressed if student-student interaction is to be used effectively.

The University Of the People - with the moniker the World’s First Tuition-Free Online University, requires students to take a first course designed to improve their capacity to collaborate with, support and network effectively. There are also a number of promising web 2.0 tools with integrated versioning control, project management, notification and communications tools that are designed to enhance the technical support of student-student interaction. But perhaps most important is that students must be given a strong and compelling advantage (in this case likely drastically reduced cost) and compatible, trialable, simple and observable tools, techniques and systems (Rogers, 2003) to make a transition from student-teacher to student-student interaction.
Another means of reducing the high cost and allowing scalability is to increase student-content interaction. Dunlap, Sobel, & Sand (2007) argue that “student-to-content interaction is the key way in which students acquire new knowledge, skills, and abilities, changing students’ understanding or perspective.” p. 22. Thorpe and Godwin (2006) provide us with one investigation in which they conclude that it is not helpful to favor either interpersonal or content interactions, noting that there were positive and negative aspects to each. As evidenced by the strong emphasis on teaching people how to read, it is generally accepted that reading content is a reasonable and effective method for gaining knowledge, with or without the intervention of an instructor or mentor.

The MOOC (Massive Open Online Course) phenomenon was first implemented by George Siemens of Athabasca University and Stephen Downes of Canada’s National Research Council and recently followed by open courses from Stanford, and has led to spin off companies such as Udacity and Coursera. These are clear demonstrations of scalable, interactive, online courses in action. MOOCs take full advantage of the power of networks to provide learning opportunities to distributed learners using open content. MOOCs are usually highly automated allowing for asynchronous and synchronous interactions among and between learners, content and instructors (Mackness, Fai, Mak & Williams, 2010). While it is there is uncertainty as to credentialing and testing of MOOC students as discussed below, there is no doubt that high quality learning experiences can be made available at very low costs to most regions of the world.

The three ways overviewed above are means to reduce the costs of formal education. However, implementing these changes in interaction models does not ensure a quality educational experience. Since time-on-task often resulting from student motivation and time availability, has long been associated with success in both face to face (Stallings, 1980) and online teaching (Castle, 2010), it is likely to remain a key determinant of student success. Students must be actively involved for learning to occur. Thus, efforts and research should focus on ensuring student-student and student-content support that induces commitment and the motivation to learn.

**Assessment and Credentialing**

We are not suggesting that student-teacher interaction needs to be, or can be, totally eliminated. Rather, we should be examining means by which we can reduce the cost of this service. One of the most important functions often bundled with student-teacher interaction relates to assessment. Without assessment and demonstration of learning, no credible institute of higher education will offer credentials or otherwise certify the learners’ qualification to hold the degree or diploma awarded. Distance educators have for a long time been challenged with the difficulty of assessing students, whom they rarely or never meet face-to-face. The usual means of overcoming this difficulty is to have students attend campus for an examination or ship the exams to a regional testing centre or to an individual invigilator/proctor, where a supervised examination takes place. More recently sophisticated systems that include locking down students’ computers, observation by web cam and keystroke identification and other forms of recognition through biometric authentication have become available. Finally there is a pedagogical trend towards the use of many forms of authentic assessment that do not require real-time invigilation including e-portfolios and project assessment in both online and classroom environments.

Universities rightfully are very protective of their role and responsibility in assuring identity, output, competency and capacity before issuing credentials that attest to these accomplishments. We have seen generations of ‘diploma mills’ offering bogus degrees and certificates and are well aware that the reputation of the university and value of the credential to students, potential employers and the university cannot be compromised. However, the issue is complicated by the social value of scarcity. If too many people attain a degree from a particular institution, then some may feel the value and certainly the exclusiveness of the award is decreased. Open universities have long struggled against this elitist restriction on higher learning, but the proliferation of credentials and massification of higher education and supposed ‘credential creep’ still inhibits many institutions from expanding their credentialing capacity.

However, it must be remembered that from a student’s perspective, with students fees and assessment must come accreditation.
Part time versus full time faculty

No issue challenges the traditional academy more than the issue of outsourcing teaching functions to part-time, as opposed to full-time tenured faculty. In the USA, the National Center for Educational Statistics (2010) reports that the now majority of active higher education instructors in the United States are adjunct faculty. Many for-profit universities, some of which offer degrees at graduate level, pride themselves that none of their faculty are isolated “ivory tower” academics and that all are immersed in the “real world” of practice. This boast raises fundamental challenges to the nature and relevance of knowledge and qualifications to teach that knowledge. Does full time employment in the academy actually reduce one’s competence or capability?

There is no single answer to this challenge, but we suspect that answers are highly discipline and context dependent. It is hard to imagine an adjunct faculty member employed, full time in industry, having the breadth, scope or relevance of knowledge that is accessible and demanded of the full time faculty member engaged in disciplines such as Shakespearean study, high energy physics or astronomy. But that same argument is harder to make in the professional faculties where active practice in education, law or medicine (to name a few) may be as, or more relevant than that of those engaged in full time study within these disciplines. Of course, this sets aside the training for and expertise in teaching in any discipline and studies do show that full time faculty have greater access to professional development training than their adjunct colleagues (Palloff & Pratt, 2011).

Undoubtedly adjunct faculty paid, in a piece work fashion for the number of courses or students they teach are much cheaper to employ than full time faculty charged with research and public service in addition to teaching. However, building an effective education program requires thoughtful content integration, knowledge of institutional politics, attention to detail and in-depth understanding of accreditation issues that adjunct faculty are neither paid for nor trained to master. Thus, strategic decisions that match institutional and discipline needs for teaching, research and service must mediate the administrative desire to hire cheaper part time faculty and the academic union desire to hire only full time tenured faculty.

We next turn to one example of an initiative recently begun by an international group of accredited universities, to pilot a radically more cost effective expansion of their education provision.

The Open Educational Resources University (OERu) Alternative

The OERu initiative is a collaboration of 13 universities on four continents that is designed to increase access to higher education by drastically reducing the cost, while maintaining quality and relying on the credentialing capacity of recognized or accredited public institutions of higher learning. The aim is to “design and implement a parallel learning universe to provide free learning opportunities for all students worldwide with pathways to earn credible post-secondary credentials” (Mackintosh, McGreal & Taylor, 2011).

The OERu model (Figure 1) seeks to leverage and support development of courses (North America) or units (Europe) built from, or created as OER. Students are encouraged to access particular courses or any combination of learning resources (high quality student-content interaction) and to create a wide variety of peer and network liaisons (high quality student-student interaction) to learn and acquire relevant skills. Partner institutions in the consortia create or acquire OER content, examinations, activities and processes by which this learning opportunity is provided, assessed and eventually accredited. This credentialing service is to be offered at prices determined by each partnering institution.

Figure 1. OERu Model from Macintosh, McGreal & Taylor, 2011
institution depending on their specific circumstances. But, in all cases the price will be considerably lower than the normal tuition rates.

Though simple in concept the OERu faces a number of operational challenges. There are, at present, sufficient OERs available to offer general Bachelors programmes in popular disciplines areas. However, this is not the case in many specific subject areas. In addition, the OER may have to be localized or adapted for different cultures, translated to other languages or further adapted to different levels for a wide range of institutions. Although each institution will be offering their own credential, there will be a growing need to accept the credentials of other participating institutions.

OERu Raises a number of challenging questions – both for its partners and other institutions. Can one time or end of course testing really test competence, learning and capacity without reference to any particular learning textbook or resources? Of course high stake testing for LSAT, GREs and many professional schools is not novel, however many faculty resent the lack of interaction associated with credit awarded exclusively by successful challenge of final examinations. Secondly, students will put pressure on institutions to accept transfer credits and even life long learning accomplishments for credit, that may not to be allowed under current university regulations. And finally to return to the issue of low cost service provision, will the OERu alternative disrupt or even destroy the current model of the partner institutions that is based in large part on students paying high fees for their courses and credentials?

Others are already implementing open course delivery models with some attempt at accreditation using “certificates”. In the Fall of 2011, professors at Stanford University offered courses for free to large numbers of learners, providing a letter to successful learners, independent of the university though a private company called Udacity, which hopes to monetize the students’ skills (Lolowich, 2012; Whittaker, 2012). And, in early 2012, the Massachusetts Institute of Technology has announced the formation of MITx that will offer course content and grant a certificate to successful learners, although this will not be identical to certificates or degrees offered through normal MIT registration. (News Report, 2011).

**Conclusion**

Network technologies and resulting social and economic innovations present disruptions to all organizations. Some industries like the sound recording and movies, retail and publishing industries have been forced to drastically re-engineer their processes and products in order to survive competition from net-based alternatives. The net is a profoundly disruptive technology. As Christenson (1997) noted, disruptive technologies are often offered at very much lower cost to traditional customers, thus opening the door to new (often low-end) markets. However, disruptive technologies, though initially providing services that are of low functionality or quality to traditional offerings, over time, often improve in many dimensions, while maintaining low cost or other competitive advantage. Thus, initial customers are not often attracted to the disruptive technology but over time they realize that an equal or better product is available at lower cost through use of the disruptive technology. We have seen this in the move to electronic watches, tablet computers, cameras, movie and sound recording products, low cost airlines, brokerages, online retailers and other services to mention just a few.

As a concrete example of this two faculty members from Stanford University sponsored a full, open online course in 2011. They were both surprised and nearly overwhelmed when over 160,000 students enrolled in the course - more than the entire student body at Stanford. Although most of these students did not complete the course 248 received perfect scores on all assignments and tests- an achievement not equaled by any of the traditional students on campus. As evidence of the potential disruption of this innovation the on-campus course dwindled from “200 students to 30 students because the online course was more intimate and better at teaching than the real-world course on which it was based.”(Salmon, 2012)

We think there is opportunity (and accompanying challenge) for educational institutions to be early adopters of low cost and no-frills model to avoid the ongoing spiral of increased costs coupled with decreased government funding and increasing student resistance and incapacity to pay high tuition fees. To make such a transition challenges many of the traditional ideals and systems of higher education institutions based on pre-net ideals and technologies. But the alternatives are also not without risk. Many will fail to adapt and go out of business; some may continue serving as elite that can afford the high costs.
The open universities have a particular challenge and opportunity to embrace these disruptive technologies and pedagogies as these initiatives speak directly to their mandate of increasing access. If both public campuses and online systems do not adapt and move to exploit these network affordances, then it leaves a tremendous opportunity that can (and will) be filled by private, for profit entrepreneurs. Whitesides (2011) tells that the race may not be to the swift, but to the cheap, noting that "affordability in the future may be the first requirement not an afterthought."

References


