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 The articles should be original, unpublished, and not in consideration for publication elsewhere at the time of submission to Educational Technology & Society and three months thereafter.

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# Journal of Educational Technology & Society

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Guest Editorial: Technology Support for Fostering Life-Long Learning of Learners with Disabilities

Fahriye Altınay1, Kürsat Cagiltay2, Mohamed Jemni3 and Zehra Altınay4

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Technology enhanced learning environments have great potential to provide equality on diffusion of knowledge, sharing resources, social involvement and participation of the disabled learners within the society. Reaching out learning facilities with the support of technology, learners with special needs can enrich their potential for their learning experience anytime and anywhere.

Studies have shown that children with special needs less likely to make decisions about their own lives (Cavet & Sloper, 2004; Franklin & Sloper, 2009; Mitchell, Malone, & Doebbeling, 2009). Also, their intellectual or physical disabilities cause lack of social inclusion. This causes problems related to their ability to make decisions on their own behalf and daily life activities. It is important to understand the nature of the learners’ special educational needs in order to help remove the obstacles they encounter. This understanding might help to support an effective implementation of special education methods with appropriate technology.

Use of technology in education of students with disabilities has a considerable history. The literature provided evidence that some technological instruments might be used effectively in the need of this group (King-Sears & Evmenova, 2007; Hasselbring & Glaser, 2000; Alper & Raharirinirina, 2006). The technology not only targets teaching related to a certain content area but also might focus on limiting the difficulties caused by a disability (Hasselbring & Glasser, 2000; Lancioni et al., 2010). The literature pays attention on the impact of technology on learning, teaching and professional developments; however, there is still a need for studies conducted about the impact of technology or technology enhanced learning environments for people with special needs in the society.

Individualized instruction and appropriate methodology are worth emphasizing in special education (Cook & Schirmer, 2003; Dettterman & Thompson, 1997). The literature provided evidence for positive effects of computer-assisted instruction on the learning process for students with intellectual disabilities, when compared to traditional instruction (Bosseler & Massaro, 2003).

Daily life skills are crucial component of education of individuals with special needs (Matson, Dempsey, & Fodstad, 2009a; Matson et al., 2009b; Neef et al., 1978). They include several skills such as toileting, grooming, and other personal care to banking and money management skills, grocery shopping, and communication and social skills. Limited acquisition of such skills possibly prevents such individuals from functioning independently within community based settings (Westling & Fox, 2004). More noticeably, limited social understanding, misinterpretation of social cues, and an inability to understand others’ perspectives will make it extremely complicated for them to develop and maintain enduring interpersonal relationships. Combined, individuals with special needs likely remain dependent on others for care and are unable to be self-productive members of society. Current research in interactive technology development for special groups, especially digital games, indicates that they may have significant roles overcoming the barriers related to teaching daily life skills. For example, research shows that bodily and touch interaction are suitable for ASD children and children with other disabilities (Alper et al., 2012).

Significantly Ramdoss et al. (2012) concluded that current research base is encouraging use of and developing technologies to teach different skills to individuals with special needs. They also pointed out that more research is needed to be more conclusive. Considering motivation, social inclusion, participation to the learning, and the societal practices with the support of technology and its facilities upon caring different types of learner disabilities within all implementations become crucial academic debate.

The literature provided evidence that use of technology to support persons with disabilities has been tested by growing number of the studies (Goldsmith & LeBlanc, 2004). Considerable effort in teaching daily living skills to individuals with intellectual disabilities and autism spectrum disorder has been provided by the researchers. Use of the technology in teaching daily living skills to individuals with special needs is a promising factor to ease educators’
and families’ teaching efforts. Even though the rates of special education services that children with mental disabilities benefited from have increased in recent years, the offering of effective educational services and the use of innovative instructional materials have not reached to the desired point yet. Therefore, quality of the present state of education offered to children with such special needs is questionable. Related to this, there is lack of information related to how instructional technology are utilized in special education.

To improve the educational programs designed for students with disabilities, educational technology might play a crucial role. An understanding of how technology can assist with instruction, knowledge of ways it can support day-to-day activities and finally the ability to teach students as well as educators and parents combined with high production of new technologies may open a new era for special education.

To this end, this special issue put emphasis on pedagogy, technology, social impact and other related aspects of technology-enhanced learning environments in life-long learning for disabled learners. The selected papers cover discussion and further implications on technology support in social life, technology enhanced learning environments and social networking tools as learning platform within the society. It attracted 20 submissions which were reviewed by international experts. Finally 11 research papers were accepted for the publication covering wide range of focus in this field.

In this issue, Silvia Baldiris, Panagiotis Zervas, Ramon Fabregat and Demetrios G. Sampson enlighten the professional development of teachers for inclusive learning in their study. They give insights on inclusive learning experiences in teacher professional development program. In addition, Tsung-Yen Chuang and Ming-Shiou Kuo provide research on a motion-sensing game-based therapy for enhancing the learning of children with sensory integration dysfunction. Fethi A. Inan, Akbar S. Namin, Rona L. Pogrund and Keith S. Jones present research for visually impaired in the focus of cybersecurity risks while using internet. Further to this, Heidi Fernandez, Zehra Altınay, Tulen Saner, Nesrin M. Bahcelerli and Fahriye Altunay give insights on the role of social media and technology for accessible tourism to enhance life long learning of disabled people. In the study of Rhonda McEwen, Anne Zbitnew and Jennifer Chatsick, a comparative analysis of traditional and tablet media for visual storytelling is provided. In addition to this, Metin Ersoy and Ahmet Güneyli give insights on the importance of social networking for orthopethically impaired learners for their life long learning. Maha Khemaja and Aroua Taamallah provided an application for users with special needs. It is aimed for learning language and communication skills through mobile tutoring system. Finally, Yosra Bouzid, Mohamed Ali Khenissi, Fathi Essalmi and Mohamed Jenni add value with their research to this field by examining educational games for sign language learning.

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References


A Motion-Sensing Game-Based Therapy to Foster the Learning of Children with Sensory Integration Dysfunction

Tsung-Yen Chuang and Ming-Shiou Kuo*
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ABSTRACT
Children with Sensory Integration Dysfunction (SID, also known as Sensory Processing Disorder, SPD) are also learners with disabilities with regard to responding adequately to the demands made by a learning environment. With problems of organizing and processing the sensation information coming from body modalities, children with SID (CwSID) usually have difficulties in the performance in one or more areas of life, such as productivity, leisure and play, or activities of daily living, resulting in the lack of learning motivation. This study tries to develop a motion-sensing digital game-based SID therapy to help such children be more engaged in physical training, in the hope that by improving their bodily-kinesthetic intelligence they can be more confident in facing various learning challenges, like social participation. This research used a Wii and Wii board with related console games, as well as an online survey system to collect responses from the children and their parents. The Chinese version of the sensory profile and clinical observations were applied to evaluate the effects of the therapy, and the triangulation method of data analysis reveals that our design has a positive effect on increasing the motivation and actions of CwSID, which the learning process relies on. Our future works, including using the Microsoft Kinect device and other gamification strategies, are also introduced.

Keywords
SID therapy, Learners with disabilities, Motion-sensing, Digital games

Introduction

The prevalence of children with sensory integration dysfunction (SID, also known as Sensory Processing Disorder, SPD) is increasing, and has caught the attention of medical professionals, parents and educational researchers (Lee & Chuang, 2013). SID is a neurological disorder in which the brain is unable to accurately process certain information received through the senses, and thus sufferers may have behavioral disorders resulting from complex multifaceted problems. However, it is not a disease that leads to brain damage or brain deterioration, and therefore neurological specialists usually are unable to effectively identify children with this condition (Ayres & Robbins, 2005). The current clinical identification of SID can be categorized into four patterns: “Visual perception and Auditory-Language Disorders,” “Tactile Defensiveness,” “Disorders involving the Vestibular System,” and “Developmental Dyspraxia.” While children with SID (CwSID) may not have all the symptoms of a certain dysfunction, they usually have several symptoms of these four patterns (Ayres & Robbins, 2005; Kranowitz & Miller, 2006; Miller & Fuller, 2007).

Ayres (1972) indicated that the human sensory integration system starts developing during the embryo stage, while the sensory integration capability evolves slowly in daily life with sports, games and other activities during one’s infancy and the primary stage of childhood. Ayres not only identified the syndromes of SID, but also the relationship between learning and sensory integrative functions. In a study sponsored by the Valentine-Kline Foundation, Ayres (1976) accomplished three objectives: exploring the relationships among academic, intellectual, language and sensory integrative functions; determining the distribution of different types of disorders and the significance of these to academic learning; and exploring the efficacy of therapeutic procedures. For the first time in occupational therapy the role of the vestibular system in learning disabilities was clarified. The neurophysiologic literature later delineated different functional areas which manifest apraxia, including postural dyspraxia, motor sequencing deficits, dyspraxia on verbal command, oral dyspraxia, and constructional dyspraxia. Ayres (1985) further connected praxis and language by stating that the former is to the physical world what speech is to the social world, because both enable interactions and transactions, and some aspects of speech and language comprehension may be closely related, even dependent upon, the development of praxis. Moreover, both praxis and language require cognitive functions of ideation and concept formation, both require integration of sensory input and both require planning that enables motor expression. As speech and language comprehension is highly related to the learning process, CwSID will have more problems in adapting to the learning environment if they also have dyspraxia, and thus finding an effective therapy to train CwSID and improve their sensory integrative ability will promote their learning performance. The
connection between SID and academic performance in a technology-enhanced learning environment can also be illustrated by our modified pyramid of learning, adapted from Williams and Shellenberger (1996), as shown in Figure 1, in which many elements discussed above serve as important building blocks of academic learning.

![Figure 1. SID and academic learning with a technology-enhanced learning environment](image1)

In the 1990’s the primary instrument for identification of SID was the Sensory Integration and Praxis Test (SIPT) (Ayres, 1989). SIPT includes measures of tactile and vestibular-proprioceptive processing, measures of form and space perception and visual-motor coordination, measures of praxis, and measures of bilateral integration and sequencing. Examiners who administer the SIPT must be carefully trained by the organization Sensory Integration International, and have extensive experience in pediatrics. While there are other tools, e.g., the Southern California Sensory Integration Test (SCSIT), and Clinical Observation and Chinese Sensory Profile, the publisher stopped selling SCSIT after the development and standardization of the SIPT. Diagnoses of SID then lead to the development of sensory integration therapy or treatment (SIT). The current approaches for treating SID are based on the intervention principles of Ayres Sensory Integration, sometimes combined with other therapies. SIT is a game-based approach to relieve the symptoms of CwSID and help them form adaptive responses during the process of game playing (Chen, 2003). The related sensory integrative equipment, like hammocks, balls, ramps and scooter boards, are still being used in SIT in some places, as shown in Figure 2.

![Figure 2. Traditional SIT equipment and environment](image2)

However, according to Taub, Ramey, DeLuca, and Echols (2004) and Wuang, Wang, Huang, and Su (2009), if the training process or environment is invariable or fixed, CwSID may easily lose their attention, patience and
enthusiasm during the therapy. Providing proper stimulation from professional training activity design and environment layout is thus an important factor in SIT. The popularity of digital games on consoles like Nintendo Wii and Microsoft Kinect, which use motion-sensing technologies, presents opportunities to create a more flexible training environment with various activity content designs, even at home. This also enables the family or parents of CwSID to get involved with SIT, with the positive effects of this noted in Lee and Chuang (2013).

In this paper we demonstrate how a Motion-Sensing Digital Game-based Sensory Integration Therapy (MSDG-SIT) could be practically established outside a traditional SIT site, by, for example, playing Wii at home. Since the parents or family of the CwSID will have more involvement than an occupational therapist in this new approach, we deployed an online survey system so that family observers could log the performance of the CwSID when training at home. It is anticipated that the proposed approach can help improve SIT, and thus foster the learning capabilities of CwSID.

**Literature review**

This section will discuss the various elements of the focal games and how they work to increase the engagement and motivation of CwSID, followed by a review of current digital games and devices, and the views of parents of CwSID who may have concerns about the use of digital games as therapy.

**Digital games and motion-sensing technology**

Digital games include TV or console games, PC games, handheld games and others using digital devices and content. In recent years such games have been used as tools for various forms of training, teaching and learning, even in medical education (Rosenberg et al., 2010). Prensky (2007) stated the key elements of digital games include: goals, conflict (or competition, challenge, and opposition), outcomes and feedback, safety, entertainment, interaction, representation or story. Two experiments conducted by Erhel and Jamet (2013) revealed that a serious game environment can promote learning and motivation, and thus learning performance, providing it includes features that prompt learners to actively process the educational content. The results of digital game-based learning (DGBL) have inspired the use of digital games in various other fields. In the context of this study, games may help CwSID to be more active in SIT, thus improving their sensory integration and processing, and linking such improvements to an academic learning environment or social learning network (Cosbey, Johnston, & Dunn, 2010). However, the games used and how they are played must be carefully considered to increase the efficacy of SIT.

Most traditional SIT activities require the trainees to perform physical actions or kinesthetic movements, e.g., postural adjustment, hopping, jumping or skipping, and in-hand manipulation. Looking at the traditional SIT environment in Figure 1, one can easily imagine how soon the children could lose their ardor for training. Although the therapist may use play therapy (Kottman, 1999) and a playground environment to create a playful atmosphere, the routine nature of training activities and almost fixed environment due to budgetary or space constraints can easily decrease the enthusiasm of both therapist and CwSID. Although digital games were first developed in the 1960’s, and have since become parts of mainstream culture, they have rarely been applied to SIT. This is perhaps because of the high price of the related equipment, the content of the games not being closely related to therapeutic training, and also the fact that standard console game controllers, such as joysticks, gamepads, keyboards and mice, are not suited for SIT training activities.

However, the commercialization of motion-sensing technologies and their application to home gaming consoles provides an opportunity to explore the use of a technology-enhanced environment for CwSID, to help foster transferable learning skills. The use of motion-sensing technology with games was boosted with the release of the Nintendo™ Wii remote, nunchuk and balance board in 2007. Users can hold the Wii remote and nunchuk and interact with the game contents on a TV screen via gesture recognition and the accelerometer and optical sensor technologies within the controllers. Figure 3 shows how the Wii remote and balance board can sense the user’s upper and lower body movements, which are then used to control the action within the game.
After the success of Nintendo Wii, in 2010 Microsoft introduced the Kinect system for its XBOX 360 home video game console. Based around a webcam-style add-on peripheral, Kinect enables users to control and interact with their console/computer without the need for a game controller, using a natural user interface with gestures and spoken commands, as seen in Figure 4. Because both the Wii and Kinect system require players to perform certain actions at the right time or in the correct way, the chained process of playing a game resembles the training activities of traditional SIT.

The reasonable prices and easy installation of such gaming systems mean that they have been used in various therapeutic settings, e.g., therapy for autistic children (Garzotto, Valoriani, & Bartoli, 2014), people with Parkinson’s disease (Galna et al., 2014), and post-stroke rehabilitation (Liao, 2012; Lohse, Hilderman, Cheung, Tatla, & Van der Loos, 2014), encouraging our research into MSDG-SIT.

Parents in therapy

Defects of traditional SIT include the fixed environment and unchanged training activities, which can decrease the trainees’ enthusiasm, and the fact that feedback from engaging in the related tasks usually only indicates success or failure, without indicating any improvements that have been made, unlike the higher scores or different visual and audio responses that can serve as encouragement in digital games. Moreover, the need to take CwSID to a specific site for therapy once or twice a week is a burden for parents. Moreover, the positive effects of the therapy may fade without continued training and practice which cannot be done at home.

Although MSDG-SIT seems an ideal solution to these problems, many parents of CwSID worry that their children will become addicted to such games. We thus introduce the concept of Filial Play Therapy (FPT) (Risë VanFleet, 2009). FPT evolved from play therapy (Cattanach, 2004; Wilson & Ryan, 2005) and is closely related to child-centered play therapy (VanFleet, Sywulak, Sniscak, & Guerney, 2011), which directly involves the parents as the agents, creating a safe atmosphere where parents can develop relationships with their children through nondirective play, while children can express themselves, try new things, learn about social rules and restrictions, develop family attachments, and develop effective social skills and bonds. Many researchers and therapists have emphasized the
importance of parental or family involvement in therapy (Alivandi-Vafa & Ismail, 2010) to enhance the curative
effects. Barlow, Parsons, and Stewart-Brown (2005) found that parental involvement in therapy had positive effects
in addressing children’s emotional, behavioral and social relational problems. Leblanc and Ritchie (2001), in their
meta-analysis of play therapy outcomes, also indicated that the participation of parents is a significant factor for
accurately predicting the effectiveness of a therapy, a view supported by many other child psychologists and
pediatric therapists (Aunola & Nurmi, 2005; Barlow et al., 2005; Wenar & Kerig, 2006).

Unlike using digital games for adult post-stroke rehabilitation or people with Parkinson’s, therapies for CwSID need
to consider the roles of parents, family members, carers and teachers (as in Kinder therapy in the USA). In this paper,
the concept of “parent” will thus be used to cover all adults who might engage in the therapy with the children.
Gameplay is an important part of children’s lives, as well as the primary bridge for them to communicate and interact
with family members. FPT can not only help the effects of MSDG-SIT therapy to last longer, but can also enhance its
effectiveness if the training frequency is increased over time (Trowell et al., 2007). This study thus developed a
supplemental log and survey system that parents used to record the performance of CwSID taking part in MSDG-
SIT, thus encouraging communication and interaction among parents, children and the therapist.

Methods and tools

With the assistance of the Occupational Therapy Department of National Cheng Kung University (NCKU-OT) in
Taiwan, six subjects with SID and their parents participated in the quasi experiment; however, one subject dropped
out because the parents did not have enough time to participate. The rest of the target subjects are aged from 8 to 11
years old and in primary school, and were treated with conventional SIT at the NCKU site and MSDG-SIT at home.
A preliminary briefing and welcome session was given to the subjects and their parents to introduce the goals of the
project in detail. Based on recommendations from professional therapists and senior researchers at NCKU-OT, the
clinical observation and the Chinese version of the sensory profile, which was derived from Dunn’s (1999) work and
translated and modified by Tsung and Chen (2008), were used to collect the pre- and post-test data. Research team
members installed and demonstrated the training program in the subjects’ homes. Monthly face-to-face interviews
with the subjects and their parents, along with the monitoring of the online survey and log system, were organized by
the research members to see if the participants needed any assistance. The cooperating therapist also joined the
discussions to provide professional opinions. The experiment lasted three months.

Clinical observation is an assessment and measurement tool that professionals commonly use in clinical situations.
The main evaluation items are related to sense adaptation disorder, postural-ocular movement disorder, bilateral
integration and sequencing deficits, somatodypraxia, and other central nervous system (CNS) immaturities, or
reflect end products of sensory integration. Under each item there are various observation sub-items corresponding to
evaluating movements and behaviors.

The Chinese version of the sensory profile uses sensory system functions, including sensory processing, adaptation,
and behavioral and emotional reactions, to assess the subjects’ levels of hyperactivity syndrome with attention deficit
disorder, autism and other disabilities, and their sensory processing capacities, as well as to understand their impacts
on the subject’s daily life. A checklist was developed in the sensory profile evaluation, which includes 14 category
scaling charts, with a total of 125 items measured using a five-point scale. Nine of the 14 categories are considered
able to represent the characteristics of the reactions shown by CwSID, including the search for sensational
excitement, emotional reaction, low muscle endurance/tension, oral sensitivity, carelessness/distraction, low login
volume, sensory sensitivity, static activity preference, and fine movement/perception. The internal coherence
reliability values of the sensory profile are between .62 and .90, and the average is .78. The re-test reliability is
inspected with the Intraclass Correlation Coefficient (ICC hereafter). The ICC of this sensory profile’s total score
is .79. Among the 14 categories, the ICC for three are between .77 and .86, and thus have good reliability; 10 of them
are between .76 and .88, and thus have average reliability; finally, one is .48, representing poor reliability. As for the
nine groups, the ICC of six categories are between .77 and .86, regarded as good reliability; the ICC of two of them
are .64 and .67, with average reliability; and one is .48, with poor reliability. The results of confirmatory factor
analysis and the global results mentioned confirm that the nine groups in this assessment scale, which was initially
designed for American SID population, are also suitable for children in Taiwan.
The quantitative data in this research were mainly based on the pre- and post-tests of the clinical observations and the sensory profiles, along with the data retrieved from the online log and survey system. The qualitative information was supplemented by interviews with the parents and discussions with the therapist during the experiment period. Consent for filming the training processes and recording the interviews were granted by both the subjects and their parents.

**The choice of digital game software**

After reviewing the literature, observing the activity design of SIT, and having repeated discussions with professional sensory integration therapists, this study chose sports games. Based on the degree of difficulty, and the aim that CwSID would easily concentrate on playing the game, we chose two games for the Chinese version of Wii: Wii Sports and Wii Fit. These were chosen for the sensory stimulation and training of the CwSID because they offer: (a) personalized adaptation training; (b) reaction capacity enhancement; (c) movement generation and feedback; (d) competition and challenge; (e) cognitive capacity improvement; (f) balance test; and (g) security features.

There are four categories in the Chinese version of Wii Fit: yoga, muscle training, aerobic exercises and balance games. This study focuses on only two of them: aerobic exercises and balance games. According to observations and analysis made by the investigators and therapists, these games are very effective treatments for vestibular system disorder, developmental dyspraxia, and visual perception and auditory-language disorders. The Wii Sports was also used to compensate for the lack of the hand movements in Wii Fit. Neither of these games requires complicated techniques, and thus should be easy for CwSID to get familiar with. Figure 5 presents the training environment in two subjects’ homes.

![Figure 5](image)

*Figure 5. The therapy training environment in two subjects' homes*

**The design of the log and survey system**

Training CwSID at home, a familiar environment, is expected to increase both the frequency and time of training, and this, along with the encouragement and support offered by the subjects’ family, is likely to improve the effectiveness of the therapy. Therefore, we developed an online log and survey system for the parents to give feedback by uploading the subjects’ performance data, so the consulting and communication could occur at any time, and the data could be easily collected and analyzed.

The log and survey system is based on LimeSurvey running on a Microsoft Windows system with an Apache server. PHP 5 and MySQL were used to provide the web-based portal, so that users can operate the system via their own accounts. A graphical interface is designed as the homepage with the game screen map of Wii Sports and Wii Fit, as seen in Figure 6. There are 44 log items for the parents to record the subject’s training performance, as shown in Appendix 1. The system can also be accessed through mobile devices, making it available at any time and place.
The online survey part is for the parents to record the subjects’ performance after each game-based training activity. Figure 7 shows a screenshot, and the survey items for each different game are provided in Appendix 2.

**Figure 7.** The online survey for the parents to evaluate the subject’s training performance

### Results and Discussion

The pre- and post-test results of the experiment group are reported in Table 1 based on the clinical observations, with a total of 32 items. The numbers indicate the degree of disability, 1 = normal, 2 = borderline performance, 3 = slightly disabled, 4 = disabled, and 5 = heavily disabled. Paired numbers preceded with “-” represent retrogression, and thus the posttest results were worse than the pretest results, while if the posttest number is less than the pretest number, this means an improvement.

**Table 1.** The pre- and post-test results of experiment group by clinical observation

<table>
<thead>
<tr>
<th>Observation items</th>
<th>Subject K</th>
<th>Subject J</th>
<th>Subject I</th>
<th>Subject A</th>
<th>Subject O</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre</td>
<td>Post</td>
<td>Pre</td>
<td>Post</td>
<td>Pre</td>
<td>Post</td>
</tr>
<tr>
<td>-------------------------------</td>
<td>-----------</td>
<td>-----------</td>
<td>-----------</td>
<td>-----------</td>
<td>-----------</td>
</tr>
<tr>
<td>Gravitational insecurity</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Aversive response to movement*</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Tactile defensiveness</td>
<td>4</td>
<td>4</td>
<td>5</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>Avoidance of sensory experiences*</td>
<td>5</td>
<td>3</td>
<td>4</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>Aversive response to smell*</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Aversive Response to Sound</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Prone extension</td>
<td>2</td>
<td>1</td>
<td>4</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Proximal joint stability-quadruped</td>
<td>2</td>
<td>1</td>
<td>3</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>Extensor muscle tone*</td>
<td>4</td>
<td>3</td>
<td>3</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Equilibrium*</td>
<td>4</td>
<td>2</td>
<td>3</td>
<td>2</td>
<td>2</td>
</tr>
</tbody>
</table>
Neck Flexion in Supine 5 4 1 1 4 3 3 2 -2 -3
Postural adjustment 3 2 2 1 2 1 4 4 4 1
Mixed/delayed hand preferencea 1 1 1 1 1 1 1 1 2 1
Crossing body midline 1 1 1 1 1 1 1 1 1 1
Right-left confusion 1 1 1 1 1 1 1 1 1 1
Catching a bounced ballb 5 3 4 2 3 2 4 2 1 1
Hopping/jumping in series of circlesa,b 2 1 2 1 2 1 2 1 2 1
Skipping 5 3 4 4 4 5 4 4 4 3
Jumping jacksc 2 1 4 3 2 1 3 2 2 1
Symmetrical stride jumpinga 3 2 4 2 2 1 3 2 1 1
Reciprocal stride jumping 4 4 5 4 5 4 4 4 2 1
Stepping over a moving objecta 4 2 1 1 2 1 2 1 1 1
Supine flexion 4 3 1 1 4 4 4 3 1 1
Sequential finger touching 3 2 4 3 2 2 4 4 1 1
In-hand manipulationc 1 1 4 3 1 1 3 2 1 1
Diadokokinesia 1 1 1 1 1 1 1 1 1 1
Associated movementsa 3 2 1 1 1 1 1 1 1 1
Distractibilitya 1 1 5 3 2 1 1 1 3 1
Finger to nosea 1 1 1 1 1 1 3 2 1 1
Level of Activity 1 1 3 2 2 1 2 2 3 1
Protective extension/support reactions 1 1 1 1 1 1 2 2 1 1
Slow (ramp) movements 1 1 1 1 1 1 1 1 1 1

Notes. *All subjects’ performances improved, except those whose status was already normal in the pre-test. 9Items which are referred to the sensory processing of balance and bilateral sequencing integration, and for which all subjects’ were pre-evaluated as having problems, although their performances for these items all improved after the experiment.

There are a total of 15 items for which all subjects’ performances were improved by the treatment, excluding those whose statuses were normal at the beginning. In the 160 paired tests, 87 were evaluated as abnormal in the pre-test, and in the post-test 71 of these 87 (82%) showed improvements, implying the effectiveness of our MSDG-SIT design. Since equilibrium (balance), hopping/jumping in a series of circles and jumping jacks are related to lower-body movements, the results imply that our proposed MSDG-SIT can enhance on vestibular balance and proprioception of lower-body sensory integration.

Table 2 summarizes the data logged by the parents from Appendix 1, as collected from the online log and survey system. Appendix 2 gives a sample of the survey items. The data has been transformed to match the five-point Likert scale, from 1 = strongly disagree to 5 = strongly agree. Because the survey was voluntary and completed at home, the number of completed survey items differs for each subject. The purpose of the survey was to involve the parents in the therapy by observing the performance of CwSID, and to indicate if they felt that it was effective.

<table>
<thead>
<tr>
<th></th>
<th>Subject K</th>
<th>Subject J</th>
<th>Subject I</th>
<th>Subject A</th>
<th>Subject O</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre</td>
<td>Post</td>
<td>Pre</td>
<td>Post</td>
<td>Pre</td>
</tr>
<tr>
<td>Adaptive movement for game content</td>
<td>2.55</td>
<td>3.24</td>
<td>3.22</td>
<td>3.85</td>
<td>2.87</td>
</tr>
<tr>
<td>Number of survey items completed</td>
<td>93</td>
<td>27</td>
<td>104</td>
<td>49</td>
<td>58</td>
</tr>
<tr>
<td>Operation and interaction with training activity</td>
<td>3.39</td>
<td>3.61</td>
<td>3.60</td>
<td>4.02</td>
<td>3.29</td>
</tr>
<tr>
<td>Number of survey items completed</td>
<td>123</td>
<td>42</td>
<td>161</td>
<td>60</td>
<td>68</td>
</tr>
<tr>
<td>Emotional expression for gameplaying</td>
<td>3.19</td>
<td>3.64</td>
<td>3.43</td>
<td>4.35</td>
<td>3.20</td>
</tr>
<tr>
<td>Number of survey items completed</td>
<td>151</td>
<td>51</td>
<td>203</td>
<td>78</td>
<td>88</td>
</tr>
</tbody>
</table>

Supplemental interviews were conducted with all the parents, and these showed that the number of survey items completed was far less than the number of times the CwSID undertook training. All subjects showed improvements in adaptive movement for game content, operation and interaction for training activity and emotional expression for
game-playing, except subject O in the final observation. The parents of subject O explained that at the beginning he showed great enthusiasm with regard to playing, and that he soon mastered the game. However, the parents noted that subject had a high level of self-discipline, and in the later observations easily got upset or frustrated if his performance dropped from the leaderboard. In comparison to subject O, the other subjects would keep trying to increase their scores, and thus raised the frequency and density of training, under the supervision of their parents. Although almost all the parents said that it was difficult to be with their children while they were training, as well as to complete the online survey, both the subjects and their parents viewed the therapy positively, and thus the frequency and density of active training increased, according to both the data and interviews, compared to the traditional SIT.

Moreover, the parents were interested in the MSDG-SIT, and some of them had great expectations with regard to its effectiveness. Interestingly, the price of Wii and other related expenses were only minor concerns. Some of the parents offered suggestions with regard to the experiment. The parents appreciated that they did not need to travel for therapy, and stated that the process had improved their relationships with their children. To sum up, the proposed approach provided opportunities for the parents to participate in and support the CwSID when working to improve their bodily-kinesthetic intelligence and skills, in an enjoyable, game-based family environment, that was accepted by both subjects and their parents.

Conclusions and future work

The results show that the proposed MSDG-SIT has better effects in improving the bodily-kinesthetic learning of CwSID compared to traditional SIT, especially for the balance, hopping/jumping in a series of circles, and jumping jacks items. The children improved their learning with regard to postural-ocular movement, bilateral integration and sequencing, as well as movement coordination. Other benefits included the subjects becoming more active in receiving therapy, and thus the training density and frequency increased, along with the resulting effects. From the parents’ perspective, both time and money could be saved by not needing to drive to the SIT site for more training. In another of our published articles, which discusses the parents’ views in more detail, the parents noted that using various games made their children to use different body movements, and they viewed the Nintendo Wii games positively. They even suggested that it would be better to increase the length of the experiment and frequency of playing the Wii games per week, to have more intensive training. In that case, the parents and therapists verified that the subjects improved significantly lot on compliance with the rules, gregarious performance, frustration tolerance, emotional control, confidence and the performance of adaptive behavior (Lee & Chuang, 2013). The idea of supplementing the MSDG-SIT with the FPT by the online log and survey system encourages the parents to participate in the process of therapy. The collected data can help the parents and therapist to monitor the performance and progress of the children, thus reducing the possibility of game addiction, encouraging children to work more on activities which need to be improved, or to get more professional opinions from the therapists. The proposed system can provide a friendly environment to foster the life-long learning of CwSID, improving not only physical coordination, but also social skills. In addition, in interviews some of the parents stated that their children showed body movements they had never demonstrated before, and would also discuss with others how best to complete the required game activities. The subjects’ showed improved abilities at manipulating objects in daily life and better balance when walking, although more work is needed to see how this therapy may affect the subjects’ academic performance.

Although using off-the-shelf Wii games in this experiment saved time with regard to game development, these games were not designed for SIT purposes, and some aspects may not suit the capabilities of CwSID. One direction for future work is thus to develop a customized motion-sensing digital game for SIT. Second, the Wii remote, nunchuk and balance board are devices that need to be held or touched by the players, and this form of interaction may not be welcomed by CwSID who have tactile defensiveness problems. Our future work will thus consider integrating the Microsoft Kinect system, as no wearable or hand-held controllers are needed with this (Chuang, Kuo, Lee, Tseng, & Hsu, 2013).

Our further research also includes applying the gamification strategy to extend and expand the therapy environment beyond that provided by digital console games, which require CwSID to stand in front of a TV screen. Gamification applies game design elements and mechanisms to gamify non-game contents, contexts and activities (in the context of the current study, the therapy that occurs when CwSID turn off the Wii console). This approach can increase user
engagement and motivation (Deterding, 2012), by making the related activities more entertaining. For example, when CwSID complete tasks they usually refuse or are afraid to do, their parents could record details of this so that their digital game performance could be enhanced with bonus points or other incentives. In this way we hope the effects of MSDG-SIT could be extended from digital game performance to the real world, therefore dissolving the boundary between the virtual gaming and the physical world.

Acknowledgements

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References


Appendix 1

Number of online surveys completed by the parents of children with SID

<table>
<thead>
<tr>
<th>Training activity</th>
<th>By Parents of Subject K</th>
<th>Subject J</th>
<th>Subject I</th>
<th>Subject A</th>
<th>Subject O</th>
<th>Subject B</th>
<th>Total</th>
<th>Invalid</th>
<th>Valid</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wii Fit Basic Test</td>
<td>6</td>
<td>30 (3)</td>
<td>5</td>
<td>5</td>
<td></td>
<td>46</td>
<td>(3)</td>
<td>43</td>
<td></td>
</tr>
<tr>
<td>BW (Strike)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0</td>
<td>0</td>
<td></td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>BW (Spin)</td>
<td>1</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td>3</td>
<td>0</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>BW (Sweep)</td>
<td>1</td>
<td>7</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>11</td>
<td>0</td>
<td>11</td>
<td></td>
</tr>
<tr>
<td>BW (vs. Player)</td>
<td>1</td>
<td>1</td>
<td></td>
<td>1</td>
<td></td>
<td>3</td>
<td>0</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>BW (vs. Wii)</td>
<td>1</td>
<td></td>
<td></td>
<td>1</td>
<td></td>
<td>3</td>
<td>0</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>BW (Bonus)</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td>0</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>BA (Penguin fishing)</td>
<td>4</td>
<td>1</td>
<td>7</td>
<td>2</td>
<td>3</td>
<td>17</td>
<td>0</td>
<td>17</td>
<td></td>
</tr>
<tr>
<td>BA (Bubble)</td>
<td>3</td>
<td>5</td>
<td>7</td>
<td>1</td>
<td>4</td>
<td>20</td>
<td>0</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>BA (Skateboard)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2</td>
<td>2</td>
<td>0</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>BA (Ski)</td>
<td>3</td>
<td>3</td>
<td></td>
<td></td>
<td>1</td>
<td>7</td>
<td>0</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>BA (Rolling ball)</td>
<td>4</td>
<td>1</td>
<td></td>
<td>1</td>
<td></td>
<td>6</td>
<td>0</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>BA (Tightrope walk)</td>
<td></td>
<td>1</td>
<td>7</td>
<td></td>
<td>1</td>
<td>1</td>
<td>10</td>
<td>0</td>
<td>10</td>
</tr>
<tr>
<td>BA (Ski Jump)</td>
<td>7</td>
<td>7</td>
<td>2</td>
<td></td>
<td>1</td>
<td>1</td>
<td>17</td>
<td>0</td>
<td>17</td>
</tr>
<tr>
<td>BA (Soccer header)</td>
<td>4</td>
<td>6</td>
<td>2</td>
<td>3</td>
<td>1</td>
<td>16</td>
<td>0</td>
<td>16</td>
<td></td>
</tr>
<tr>
<td>BX (Punch)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>BX (Sandbag)</td>
<td></td>
<td>1</td>
<td></td>
<td></td>
<td>1</td>
<td>2</td>
<td>0</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>BX (vs. Player)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>BX (vs. Wii)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>BX (Dodge)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0</td>
<td>0</td>
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</tr>
<tr>
<td>AB (Hula hoop)</td>
<td>3 (1)</td>
<td>4</td>
<td>4</td>
<td>1</td>
<td>1</td>
<td>13</td>
<td>(1)</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>AB (Jog)</td>
<td>2</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td></td>
<td>9</td>
<td>0</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>AB (Hula trick)</td>
<td>4</td>
<td>1</td>
<td></td>
<td>2</td>
<td></td>
<td>7</td>
<td>0</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>AB (Tempo boxing)</td>
<td>4</td>
<td></td>
<td>1</td>
<td>1</td>
<td></td>
<td>6</td>
<td>0</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>AB (Tempo pedal)</td>
<td>1</td>
<td>3</td>
<td></td>
<td>2</td>
<td></td>
<td>6</td>
<td>0</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>AB (Easy jog)</td>
<td>2</td>
<td>1</td>
<td></td>
<td>1</td>
<td></td>
<td>4</td>
<td>0</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>AB (Easy Pedal)</td>
<td></td>
<td></td>
<td>1</td>
<td>2</td>
<td></td>
<td>3</td>
<td>0</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>AB (Run with Wii)</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td></td>
<td>4</td>
<td>0</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>AB (Rhythm pedal)</td>
<td>3</td>
<td>4 (1)</td>
<td>2</td>
<td></td>
<td>1</td>
<td>10</td>
<td>(1)</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>BB (Bat practice)</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td></td>
<td></td>
<td>4</td>
<td>0</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>BB (Home run derby)</td>
<td>2</td>
<td>2</td>
<td>4</td>
<td></td>
<td>1</td>
<td>9</td>
<td>0</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>BB (vs. Player)</td>
<td>2</td>
<td></td>
<td>1</td>
<td></td>
<td>3</td>
<td>0</td>
<td>3</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>BB (vs. Wii)</td>
<td>1</td>
<td>1</td>
<td>3</td>
<td>1</td>
<td>1</td>
<td>8</td>
<td>0</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>BB (Till strike out)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>4</td>
<td>(1)</td>
<td>1</td>
<td>5 (1)</td>
<td>4</td>
</tr>
<tr>
<td>TN (Targeting)</td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>TN (Zone targeting)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>TN (vs. Player)</td>
<td>3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>TN (vs. Wii)</td>
<td>2</td>
<td>1</td>
<td></td>
<td>1</td>
<td></td>
<td>4</td>
<td>0</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>TN (Swing back)</td>
<td>2</td>
<td>3</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>9</td>
<td>0</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>GF (One shot to green)</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td>0</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>GF (Hole in one)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td>0</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>GF (Targeting)</td>
<td>3</td>
<td></td>
<td></td>
<td>1</td>
<td>4</td>
<td>0</td>
<td>4</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>GF (vs. Player)</td>
<td>1</td>
<td></td>
<td></td>
<td>1</td>
<td>2</td>
<td>0</td>
<td>2</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>GF (vs. Wii)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

**Sum** 56 (1) 28 119 (5) 29 38 15 285 (6) 279

Appendix 2

Example of Survey Items for Wii Sports Tennis: Swing back

(Completed by the parents after observing the performance of the subject child during the home training game activity, originally coded in Chinese.)

**Expectations:** Upper-body movement, eye-hand coordination, proprioception, visual stimulation, motor planning.

Recording Date:
Playing starts at what time:
Times played:
Time spent playing:

**Adaptive movement for game content**
1 = strongly disagree, 2 = disagree, 3 = undecided, 4 = agree, 5 = strongly agree

(12345) Imitating actual swing postures
(12345) Planning swing
(12345) Swing at the accurate timing
(12345) Master forehand
(12345) Master backhand

**Operation and interaction with training activity**
1 = strongly disagree, 2 = disagree, 3 = undecided, 4 = agree, 5 = strongly agree

(12345) Training motivation is increased by this game
(12345) The goals of this game enhance the motivation
(12345) The challenges/competition of this game give space for children to learn and solve problems
(12345) The child’s motivation is increased when retrying the game after failing
(12345) The game resembles virtual reality for a real-life simulation
(12345) The game provides opportunities for interaction with others
(12345) The child need more practice with this game

**Emotional expression for game-playing**
1 = strongly disagree, 2 = disagree, 3 = undecided, 4 = agree, 5 = strongly agree

(12345) The child likes to play this time
(12345) The child feels frustrated or upset when playing this time
(12345) The child feels fulfilled when playing this time
(12345) The child feels joyful and immersed in the game (as seen in laughter, enthusiasm, aggression, and actively expressing emotions)
(12345) Intention to compete (vs. Wii or vs. Player)
(12345) Coordination of body movement improved (in swinging, hopping, etc.)
(12345) Intention to share and socialize increased (inviting others, leading the game)
(12345) Intention to plan new solutions increased (changing to forehand/backhand, using other avatars, etc.)
(12345) Socialization improved (consoling him/herself after failing, making others laugh, expressing humor, etc.)

Who else played with the child this time: (e.g., no one, father, mother, brother, sister, or friend.)

Other Comments:

Family support is key to successful therapy. Thank you for your participation!
Developing Teachers’ Competences for Designing Inclusive Learning Experiences

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*Corresponding author

ABSTRACT
Inclusive education, namely the process of providing all learners with equal educational opportunities, is a major challenge for many educational systems worldwide. In order to address this issue, a widely used framework has been developed, namely the Universal Design for Learning (UDL), which aims to provide specific educational design guidelines to ensure accessibility of all learner types to the learning environment. On the other hand, nowadays teachers are provided with ample opportunities for freely accessing a wide number of Open Educational Resources (OERs) that are available through existing OER initiatives. Within this context and following the UDL principles, teachers are expected to be able to select and transform and/or augment OERs to fit their learners’ diverse needs towards delivering inclusive learning experiences. This calls for developing specific teachers’ competences that are aligned with existing competence frameworks such as the Competence Framework for Inclusive Teachers (CFIT) towards effectively engaging them in the aforementioned process. To this end, the scope of this paper is to present the design, implementation and evaluation of a teacher professional development program (PDP) aligned with CFIT for designing inclusive OERs by applying the UDL principles. The evaluation results of the teacher PDP demonstrated its added value for developing teachers’ competences towards designing inclusive learning experiences for their students.

Keywords
Inclusive learning, Inclusive education, Universal design for learning, Teacher training, Teacher professional development, Competence framework, Inclusive teacher

Introduction
Inclusive education has been the focus and a major challenge for many educational systems worldwide (Srivastava et al., 2015). Inclusive education aims to ensure that learners with diverse needs and preferences (such as learners with disabilities) can have equal opportunities in accessing learning resources, services and experiences in general (Florian & Linklater, 2010). Therefore, inclusive education can reduce inequalities and increase the competences of all people, independently from their diverse needs and preferences, leading to increased innovation and productivity and, subsequently, to long-term economic viability (Hanushek & Woessmann, 2010; UNESCO, 2005).

In order to support inclusive education, specific educational design frameworks have been proposed such as Differentiated Instruction (Tomlinson & McTighe, 2006) and the Universal Design for Learning (UDL) (Meyer et al., 2014; CAST, 2014; Rose & Meyer, 2002). These frameworks recognize the broad diversity of learners with respect to ability, language, culture, gender, age and other forms of human difference and they provide specific educational design guidelines to ensure accessibility of all learner types to the learning environment. UDL has been recognized as the mostly used framework for the design and development of curricula that is effective and inclusive for all learners (Hall et al., 2012).

At the same time, teachers are provided with ample opportunities for freely accessing a wide number of Open Educational Resources (OERs) that are available through existing OER initiatives developed by large organizations/institutions such as UNESCO OER Community, Open Education Europa, Carnegie Mellon Open Learning Initiative, MIT’s OpenCourseWare, Stanford’s iTunes and Rice University’s Connexions or by communities/consortia such as MERLOT and OER Commons (Zervas et al., 2014a; Conole, 2013; UNESCO, 2012). Within this context, teachers are expected to be able to select and appropriately transform and/or augment (following the UDL principles), OERs to fit their learners’ diverse needs towards delivering inclusive learning experiences (Treviranus et al., 2014). This calls for developing specific teachers’ competences towards effectively engaging them in the aforementioned process. The essential competences that are needed in order for a teacher to be considered as
“inclusive” have been identified in the Competence Framework for Inclusive Teachers (CFIT), which has been developed by a major European initiative namely “The Teacher Education for Inclusion (TE4I)” (Watkins & Donnelly, 2013). As a result, teacher professional development programmes that aim to train teachers in the process of designing inclusive learning experiences should be aligned with CFIT.

The main goal of this paper is to present the design, implementation and evaluation of a teacher professional development program (PDP) aligned with the CFIT, for designing inclusive OERs by applying the UDL principles. The proposed teacher PDP has been developed in the context of a European initiative, namely the Inclusive Learning Project (Zervas et al., 2014b). The results from the evaluation of the teacher PDP demonstrated its added value for developing teachers’ competences towards designing inclusive learning experiences for their students.

The remainder of the paper is organized as follows: following this introduction, the background section provides an overview of UDL and its main principles, as well as an overview of the CFIT framework and its main competence areas. The next section presents and discusses existing teacher professional development programmes on inclusive education, in order to identify their limitations in terms of scope and appropriately inform the scope of the proposed teacher PDP. Afterwards, we present our proposed teacher PDP and more specifically the delivery method adopted, the training modules developed and how they are aligned with CFIT, as well as the assessment method selected. Then, we present the methodology that was followed for evaluating the proposed teacher PDP. The next section presents and discusses the evaluation results from the implementation of proposed teacher PDP. Finally, we discuss our main conclusions and our future work in this agenda.

Background

Universal Design for Learning (UDL)

UDL has been developed by the Centre for Applied Special Technology (CAST) as a framework of lesson planning that helps teachers to create lessons that are inclusive for a broad range of learners in their classrooms (CAST, 2014). UDL involves the proactive application of educational design concepts, pedagogical knowledge and technology to create learning experiences that is accessible and engaging to learners with diverse needs (King-Sears, 2009). More specifically, UDL introduces teachers to three principles for overcoming barriers that are particularly presented within a learning environment, namely (Meyer et al., 2014; CAST, 2014; Rose & Meyer, 2002):

- **Representation:** It refers to modifications that can be made to educational resources that would make them accessible to learners with diverse needs. This means that teachers must learn how to present educational resources so that it is not just oral or in print, but so the educational resources is represented through a variety of modalities and methods such as videos, websites, pictures etc.

- **Action and Expression:** It refers to alternative methods of communication for learners with diverse needs. More specifically, UDL requires teachers to provide learners with a variety of options to communicate and demonstrate what they have learnt, so that to move beyond traditional tests and papers to include options, which allow learners to capitalize on their special abilities or talents.

- **Engagement:** It refers to the use of strategies that involve learners with diverse needs in the learning process. More specifically, teachers need to implement different classroom strategies that empower their learners and draw them into the learning by providing choices, reducing anxiety, and rewarding effort.

Along with the three aforementioned principles, the UDL framework, presents 9 guidelines and 33 specific checkpoints under the aforementioned main principles, detailing how to overcome the barriers inherent in most existing curricula and serve as the basis for building in the options and the flexibility that are necessary to maximize learning opportunities for learners with diverse needs (CAST, 2014). Following this overview, it should be mentioned that UDL is a general framework which can be also applied in technology–enhanced learning environments. As a result, UDL has been selected to be the foundation of the proposed teacher PDP.

Competence Framework of Inclusive Teachers (CFIT)

The essential competences that are needed in order for a teacher to be considered as “inclusive” have been proposed by a major European initiative namely “The Teacher Education for Inclusion (TE4I)” (Watkins & Donnelly, 2013).
The TE4I project has involved policy makers (responsible for teacher education and inclusive education), as well as general and specialist teacher trainers from 25 European countries towards identifying a Competence Framework for Inclusive Teachers (CFIT). The overview of this competence framework is presented in Table 1.

<table>
<thead>
<tr>
<th>Core values</th>
<th>Competence areas</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Valuing Learner Diversity: Learner difference is considered as a resource and an asset to education</td>
<td>1.1 Conceptions of inclusive education</td>
</tr>
<tr>
<td>2. Supporting All Learners: Teachers have high expectations for all learners’ achievements.</td>
<td>1.2 The teacher’s view of learner difference</td>
</tr>
<tr>
<td>3. Working With Others: collaboration and teamwork are essential approaches for all teachers</td>
<td>2.1 Promoting the academic, practical, social and emotional learning of all learners</td>
</tr>
<tr>
<td>4. Personal Professional Development: teaching is a lifelong activity and teachers take responsibility for their lifelong learning.</td>
<td>2.2 Effective teaching approaches in heterogeneous classes</td>
</tr>
<tr>
<td>5. Understanding differences in learners' learning styles and abilities</td>
<td>3.1 Working with parents and families</td>
</tr>
<tr>
<td>6. Working with a range of other educational professionals</td>
<td>3.2 Working with a range of other educational professionals</td>
</tr>
<tr>
<td>7. Understanding the importance of cultural diversity</td>
<td>4.1 Teachers as reflective practitioners</td>
</tr>
<tr>
<td>8. Initial teacher education as a foundation for ongoing professional learning and development</td>
<td>4.2 Initial teacher education as a foundation for ongoing professional learning and development</td>
</tr>
</tbody>
</table>

As the Table 1 depicts, the framework proposed by TE4I was based upon multi-faceted areas of competence linked to agreed core values for inclusive education. Furthermore, each competence area is comprised of three elements, namely a certain attitude, a certain piece of knowledge or level of understanding and the skills in order to implement these in a practical situation (Watkins & Donnelly, 2013). Table 2 presents the number of competences in terms of knowledge, skills and attitudes that underpins each competence area of CFIT.

<table>
<thead>
<tr>
<th>Competence areas</th>
<th>Description per competence area</th>
<th># Competences per element</th>
<th>Total competences</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1 Conceptions of inclusive education</td>
<td>The competences in this area includes understanding that inclusion is based on access to education, participation and educational attainment of all learners</td>
<td>Knowledge: 5 Skill: 6 Attitude: 4</td>
<td>15</td>
</tr>
<tr>
<td>1.2 The teacher’s view of learner difference</td>
<td>The competences underpinning this area are related to providing value to differences and identify the best ways to respond to diversity</td>
<td>Knowledge: 5 Skill: 5 Attitude: 5</td>
<td>15</td>
</tr>
<tr>
<td>2.1 Promoting the academic, practical, social and emotional learning of all learners</td>
<td>The competences in this area include adopting teaching approaches, which encourage social development and interaction among learners</td>
<td>Knowledge: 3 Skill: 8 Attitude: 7</td>
<td>18</td>
</tr>
<tr>
<td>2.2 Effective teaching approaches in heterogeneous classes</td>
<td>The competences underpinning this area are related to understanding the process of differentiation of teaching approach and educational resources to address learners preferences and diverse needs</td>
<td>Knowledge: 9 Skill: 13 Attitude: 6</td>
<td>28</td>
</tr>
<tr>
<td>3.1 Working with parents and families</td>
<td>The competences underpinning this area are related to the efficient communication with parents and family members of different cultural, ethnic, linguistic and social backgrounds.</td>
<td>Knowledge: 3 Skill: 2 Attitude: 3</td>
<td>8</td>
</tr>
<tr>
<td>3.2 Working with a range of other educational professionals</td>
<td>The competences in this area include contributing to wider school partnerships with other schools, community organizations and other educational organizations</td>
<td>Knowledge: 6 Skill:8 Attitude:3</td>
<td>17</td>
</tr>
<tr>
<td>4.1 Teachers as reflective practitioners</td>
<td>The competences in this area are related to methods and strategies for evaluating teachers’ own work and performance</td>
<td>Knowledge: 5 Skill:3 Attitude:4</td>
<td>12</td>
</tr>
<tr>
<td>4.2 Initial teacher education as a foundation for ongoing professional learning and development</td>
<td>The competences underpinning this area include understanding time management strategies that</td>
<td>Knowledge: 2 Skill:4</td>
<td>11</td>
</tr>
</tbody>
</table>
ongoing professional learning and development will accommodate possibilities for pursuing in-service development opportunities  

As we can notice from Table 2, a total number of 124 competences are included in the CFIT. These competences can be used as a guide for the design and implementation of teacher PDPs, namely identifying appropriate training modules that specifically address these competences.

**Related work: Existing teacher professional development programmes on inclusive education**

A comparative analysis of the characteristics of 13 teacher PDPs on inclusive education has been already presented in Kurniawati et al. (2014). In the context of the present study, we re-visit these 13 teacher PDPs and we present their main scope in terms of teachers’ competences addressed (i.e., knowledge, skills and attitudes). The main aim of this meta-review was to identify limitation of their scope and accordingly inform the scope of our proposed teacher PDP.

**Table 3. Existing teacher PDPs on inclusive education**

<table>
<thead>
<tr>
<th>No.</th>
<th>Authors</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Allday et al. (2012)</td>
<td>Focus on improving teachers’ skills regarding on-task behaviour, task completion and correct academic responses when teaching students with emotional/behavioural disabilities</td>
</tr>
<tr>
<td>2</td>
<td>Carroll et al. (2003)</td>
<td>Focus on improving teachers’ attitudes regarding the inclusion of students with different disabilities in their classrooms</td>
</tr>
<tr>
<td>3</td>
<td>Edwards et al. (2006)</td>
<td>Focus on improving teachers’ attitudes and knowledge regarding the inclusion of students with different disabilities in their classrooms</td>
</tr>
<tr>
<td>4</td>
<td>Gürsel (2007)</td>
<td>Focus on improving teachers’ attitudes regarding the inclusion of students with physical disabilities in their classrooms</td>
</tr>
<tr>
<td>5</td>
<td>Leblanc et al. (2009)</td>
<td>Focus on improving teachers’ attitudes and knowledge regarding the inclusion of students with autistic spectrum disorder in their classrooms</td>
</tr>
<tr>
<td>6</td>
<td>Lieberman &amp; Wilson (2005)</td>
<td>Focus on improving teachers’ attitudes regarding the inclusion of students with visual impairment and deaf-blindness in their classrooms</td>
</tr>
<tr>
<td>7</td>
<td>Male (2011)</td>
<td>Focus on improving teachers’ attitudes regarding the inclusion of students with different disabilities in their classrooms</td>
</tr>
<tr>
<td>8</td>
<td>Miller et al. (2000)</td>
<td>Focus on improving teachers’ knowledge regarding the inclusion of students with different disabilities in their classrooms</td>
</tr>
<tr>
<td>9</td>
<td>Rae et al. (2011)</td>
<td>Focus on improving teacher knowledge and understating regarding the defining criteria of intellectual disability</td>
</tr>
<tr>
<td>10</td>
<td>Renshaw et al. (2008)</td>
<td>Focus on improving teachers’ knowledge regarding the inclusion of students with behavioural and attention problems in their classrooms</td>
</tr>
<tr>
<td>11</td>
<td>Sari (2007)</td>
<td>Focus on improving teachers’ knowledge regarding the inclusion of students with hearing impairments in their classrooms</td>
</tr>
<tr>
<td>12</td>
<td>Sharma et al. (2008)</td>
<td>Focus on improving teachers’ attitudes regarding the inclusion of students with different disabilities in their classrooms</td>
</tr>
<tr>
<td>13</td>
<td>Wolery et al. (1997)</td>
<td>Focus on improving teachers’ skills regarding their instruction in the classroom towards addressing students with different disabilities</td>
</tr>
</tbody>
</table>

As we can notice from Table 3, most of the teacher PDPs (namely 7 out of 13) focus on developing teacher’s competences related to dealing and interacting with students with specific disabilities in the classroom. On the other hand, there are also teacher PDPs (6 out of 13) that focus on developing teacher’s competences related to dealing and interacting with students with different disabilities in the classroom. However, none of these teacher PDPs addresses the pedagogical perspective of facilitating teachers to design their lessons, so as to be effective for students with different disabilities in their classrooms. Next, we aim to address this issue in the teacher PDP arena by presenting our proposed teacher PDP that focuses on designing inclusive learning experiences aligned with UDL and CFIT.
Design and development of a teacher professional development program

The proposed teacher PDP has been developed in the context of a European initiative, namely the Inclusive Learning Project (Zervas et al., 2014b) and the target group were teachers and trainers of primary/secondary schools and vocational training institutions. The main objective of the proposed teacher PDP is to facilitate teachers/trainers to design technology-supported inclusive lessons in the form of OERs by following the UDL principles and the ADDIE Educational Design Model (Dick et al., 2005). Next, we describe the delivery method adopted for the proposed teacher PDP, the training modules developed, as well as the assessment method selected.

Delivery method

The proposed teacher PDP was designed in a blended learning modality. The duration of the program is 30 hours, comprising 18 hours of face-to-face learning activities and 12 hours of online learning activities. The online learning activities of the proposed teacher PDP were implemented with the use of a customized version of ATutor (Gay et al., 2009). ATutor is an open source accessible Course Management System (CMS), developed by the Adaptive Technology Resource Centre of the University of Toronto and it has been developed following ISO/IEC Standard 24751 “Individualized Adaptability and Accessibility in e-Learning, Education and Training” (ISO/IEC, 2008a; ISO/IEC, 2008b) and W3C Web Content Accessibility Guidelines 2.0 (Caldwell et al., 2008). To this end, the selected CMS can demonstrate to the participated teachers/trainers how accessibility preferences can be applied in the system towards supporting people with disabilities.

Additionally, ATutor provides access to collaboration tools enabling participating teachers/trainers to easily communicate and collaborate with other teachers for sharing ideas. These tools include a forum, as well as a private messaging tool.

Finally, ATutor provides access to a web content authoring tool, namely TinyMCE (Gay, 2004), which allows teachers to create their own web-based educational resources. TinyMCE has been customized in order to provide with better support when participated teachers/trainers are developing accessible web-based educational resources, by following the W3C Web Content Accessibility Guidelines 2.0. Moreover, TinyMCE has been adapted to integrate a plugin, which uses the AChecker (Gay & Li, 2010) automatic validation service in order to present the participated teachers/trainers with a report of possible errors or warnings about the accessibility of the web-based educational resources that they are developing with TinyMCE (Avila Garzón et al., 2014).

Training modules

Table 4 presents the training modules of the proposed teacher PDP, their mapping to the competence areas of CFIT, as well as the number of CFIT competences addressed per competence area by each training module. This mapping ensures that our proposed teacher PDP is fully aligned with the CFIT. Moreover, as we can notice from Table 4, 47 total competences are addressed by the training modules of the proposed teacher PDP, which constitute the 37.90% of the total CFIT competences. Furthermore, the focus of the proposed teacher PDP specifically addresses competences which were not explicitly aimed at in the existing teacher PDPs.

<table>
<thead>
<tr>
<th>Training modules</th>
<th>Description</th>
<th>Competence areas addressed</th>
<th>Number of competences addressed per competence area</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Inclusive Education</td>
<td>This module aims to introduce teachers the importance of designing learning experiences for learners with diverse needs. Moreover, it aims to presents policies at national and international level for addressing learners’ diversity.</td>
<td>1.1</td>
<td>3 out of 15</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.2</td>
<td>4 out of 15</td>
</tr>
<tr>
<td>2. Universal Design for Learning</td>
<td>The purpose of this module is to present to the teachers the concepts related to the UDL, its main principles and guidelines per principle. Moreover, it provides examples of</td>
<td>2.1</td>
<td>2 out of 18</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2.2</td>
<td>2 out of 28</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3.1</td>
<td>3 out of 8</td>
</tr>
</tbody>
</table>
3. Designing Inclusive Lessons as Open Educational Resources (OERs)

This module presents to the teachers the process of designing inclusive lessons in the form of OERs following the successful implementation of the UDL principles. The ADDIE educational design model (Dick et al., 2005) and the UDL principles were used to guide this process.

4. Accessibility of OERs

This module engages teachers in the process of developing accessible OERs following the W3C Web Content Accessibility Guidelines 2.0 and with the use of TinyMCE web content authoring tool. Two main deliverables are produced: (a) a description of the teaching approach and relevant learning activities and (b) an analysis of possible barriers for executing these learning activities and how these barriers can be overcome based on UDL principles.

5. Validating OERs’ Accessibility

This module engages teachers in the process of validating the accessibility and inclusiveness of OERs created in the previous training module. The outcome of this phase is two deliverables: (a) a report with feedback from the students regarding the accessibility of the educational resources used in the lesson and (b) a report with feedback from the students regarding the impact of the UDL principles during the delivery of the lesson.

Assessment method

The assessment method that was selected for the proposed teacher PDP was the development of a project with intermediate deliverables. More specifically, the participated teachers/trainers are requested to design and develop a technology-supported inclusive lesson as OER by following the UDL principles, as well as the W3C web content accessibility guidelines 2.0.

The technology-supported inclusive lesson is being designed and developed with intermediate deliverables that follow the five (5) phases of the ADDIE educational design model (Dick et al., 2005). Additionally, for the preparation of each intermediate deliverable, the participated teachers/trainers can collaborate by using the collaboration tools offered by ATutor. More precisely, the phases that are followed are summarized below:

- **Analysis Phase:** During this phase, the educational problem of the inclusive lesson is identified and the contextual parameters of the educational environment are analyzed. Moreover, the targeted students’ characteristics and their existing competences (knowledge, skills and ideally attitudes too) are defined. The outcome of this phase is two deliverables, namely: (a) a narrative description of the inclusive lesson and (b) a description of the profile of the targeted students following the UDL principles.

- **Design Phase:** During this phase, the educational objectives to be achieved are defined, an appropriate teaching approach for attaining these objectives is selected, and appropriate assessment methods are decided towards evaluating whether and to what extent the educational objectives have been met. Two are also the main deliverables of this phase, namely: (a) description of the teaching approach to be followed, as well as the relevant learning activities and (b) analysis of possible barriers for executing these learning activities and how these barriers can be overcome based on UDL principles.

- **Develop Phase:** During this phase, the development or selection of appropriate educational materials and the arrangement of the delivery setting is performed for the inclusive lesson that has been designed in the previous phase. More specifically, during this phase the participated teachers/trainers prepare the learning activities of their lesson with ATutor and they develop accessible web-based educational resources to support these activities by using the TinyMCE web content authoring tool following the W3C web content accessibility guidelines 2.0. The main outcome of this phase is (a) the inclusive lesson developed in ATutor, along with accessible web-based educational resources and (b) a report describing the process followed for developing the lesson in ATutor.

- **Implement Phase:** During this phase, the technology-supported inclusive lesson is delivered to the targeted students. The main outcome of this phase is a report with the results from the implementation and emphasis on the application of the UDL principles during the delivery of the lesson.

- **Evaluation Phase:** During this phase, an evaluation of the technology-supported inclusive lesson is performed by the students. The outcome of this phase is two deliverables, namely (a) a report with feedback from the students regarding the accessibility of the educational resources used in the lesson and (b) a report with feedback from the students regarding the impact of the UDL principles during the delivery of the lesson.
The first three phases and their accompanying deliverables were prepared by the participating teachers/trainers during the delivery of the PDP, namely within the 30 hours. The deliverables that correspond to the next two phases (namely implementation and evaluation) were prepared by the participating teachers/trainers within one month after the end of the PDP, so as to be able to implement and evaluate their lessons with their students.

Finally, it should be mentioned that the intermediate deliverables per phase were assessed by a group of experts, who provided feedback to the participated teachers/trainers after the assessment of each deliverable. Moreover, each participating teacher/trainer was assigned a score in a range of 0 to 5, based on the submitted deliverables per phase. An overall score in a range of 0 to 5 per participating teacher/trainer was calculated as the average from the individual scores assigned to the five (5) phases of the ADDIE educational design model. Finally, the score was distributed to the following performance levels: (a) inadequate performance [0, 2], (b) adequate performance (2, 3], (c) (3, 4] satisfactory performance and (d) excellent performance (4, 5).

**Evaluation method**

The scope of the evaluation was to assess the impact of the teacher PDP on the participant's competence development. The PDP was offered in a single run as part of a MSc programme on ICT hosted by the Universidad Pontificia Bolivariana in Colombia between April 2014 to June 2014.

**Participants**

The evaluation was conducted with $N = 47$ primary and secondary teachers, as well as trainers for initial vocational education. This diversity was important towards ensuring that the proposed teacher PDP can address the particularities of different educational levels. Moreover, 65.96% ($N = 31$) of our sample was female participants, whereas 34.04% ($N = 16$) was male participants. This distribution can be marginally considered as an adequate gender balance in our sample. The majority of the participants were experienced teachers/trainers (69% of the participants had more than 6 years of teaching experience). Furthermore, the majority of the teachers/trainers in our sample were moderately experienced in using ICT for their daily teaching activities (72.34% of the participants). Thus, overall we consider that our sample is well selected for the purpose of our evaluation. Finally, the participants’ prior experience in designing inclusive lesson plans were low, as indicated by the pre-test which was conducted as part of the evaluation process (see following section).

**Methodology**

The participants were divided in three (3) cohorts following the policy of the university, which does not allow more than 20 students to participate to a single run of a training programme. Moreover, in order to equally distribute the participants of our sample based on their demographics to the different cohorts, the distribution presented in Table 5 was decided.

<table>
<thead>
<tr>
<th>Cohort no.</th>
<th>$N$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cohort #1</td>
<td>16</td>
</tr>
<tr>
<td>Cohort #2</td>
<td>17</td>
</tr>
<tr>
<td>Cohort #3</td>
<td>14</td>
</tr>
<tr>
<td>Total</td>
<td>47</td>
</tr>
</tbody>
</table>

The methodology used for the evaluation included the following steps, which have been proposed in a similar study by Spooner et al. (2007):

- **Pre-test:** Participating teachers/trainers per cohort were presented with a case study to design in narrative format an inclusive lesson plan with a clear description of how they would use the three principles of UDL to address people with disabilities. Moreover, as aforementioned the pre-test results were used in order to define the participants’ prior experience in designing inclusive lesson plans.
- **Post-test:** After the completion of the PDP, a similar case study with the same complexity was presented to the participated teachers/trainers per cohort and they were asked to repeat the process executed during pre-test.
The inclusive lesson plans prepared by the participants were assessed by a group of experts after the pre-test and post-test using the same assessment rubric defined by Spooner et al. (2007) and presented in Table 6. More specifically, the assessment rubric consisted of a 3-point scale and assessed the participants’ inclusive lesson plans using the three principles of UDL. There was a maximum number of 6 points available on the rubric. Points were distributed based on three given criteria: (a) 1 points if there was not a clear description of each component, (b) 2 points if one or two modifications were discussed, and (c) 3 points if three or more modifications were discussed.

Table 6. UDL assessment rubric (Spooner et al., 2007)

<table>
<thead>
<tr>
<th>UDL principle</th>
<th>1 point</th>
<th>2 points</th>
<th>3 points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Representation</td>
<td>No clear description of equal access to all students</td>
<td>Introduce one or two options of materials to provide equal access, but needs to be explained more in depth</td>
<td>Introduce three or more options of material to provide equal access to all students; give clear and precise explanations.</td>
</tr>
<tr>
<td>Expression</td>
<td>No clear description of providing alternative communication methods for all students</td>
<td>Introduce at least one alternative communication method, but needs to be explained more in depth</td>
<td>Introduce two or more alternative communication methods, gives clear and precise explanations.</td>
</tr>
<tr>
<td>Engagement</td>
<td>No clear description of strategies to involve or engage all students including those with disabilities</td>
<td>Introduce one or two strategies to involve all students including those with disabilities, but needs to be explained more in depth</td>
<td>Introduce two or more strategies to involve students including those with disabilities, gives clear and precise explanations.</td>
</tr>
</tbody>
</table>

Another important indicator for the evaluation of the PDP is the scores achieved by the participants of each cohort to the intermediate deliverables of the project of designing and developing a technology-supported inclusive lesson by following the ADDIE educational design model, as well as the UDL principles and the W3C web content accessibility guidelines 2.0.

Evaluation results

Table 7 presents quantitative data analysis results of the pre-test and post-test scores received by the participated teachers/trainers at each cohort related to the application of UDL principles for designing inclusive lesson plans.

Table 7. Mean scores and standard deviations on the pre-test and post-test for the different cohorts

<table>
<thead>
<tr>
<th>UDL principles</th>
<th>Cohort #1 (N = 16)</th>
<th>Cohort #2 (N = 17)</th>
<th>Cohort #3 (N = 14)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre-test</td>
<td>Post-test</td>
<td>Pre-test</td>
</tr>
<tr>
<td>Representation</td>
<td>1.06</td>
<td>0.25</td>
<td>2.88</td>
</tr>
<tr>
<td>Expression</td>
<td>1</td>
<td>0</td>
<td>2.88</td>
</tr>
<tr>
<td>Engagement</td>
<td>1</td>
<td>0</td>
<td>2.88</td>
</tr>
</tbody>
</table>

As we can notice from Table 7, all cohorts demonstrated a considerable amount of growth between pre-test and post-test and this is applicable for all UDL principles. This clearly demonstrates the added value of the proposed teacher PDP in terms of developing teachers’ competences in the process of applying UDL principles for designing inclusive lesson plans.

Table 8 presents quantitative data analysis results of the scores achieved by the participating teachers/trainers to the intermediate deliverables per ADDIE phase at each cohort.

As we can notice from Table 8, all cohorts achieved scores within the excellent performance level for all phases of the ADDIE educational design model. This highlights that the proposed teacher PDP can significantly develop teachers’ competences for designing, developing implementing and evaluating a technology-supported inclusive
lesson. Additionally, it is worth mentioning that the highest scores have been achieved by participating teachers/trainers of cohort #2. This is aligned with the results of Table 7, which demonstrate the significant growth between pre-test and post-test of Cohort #2.

Table 8. Mean scores and standard deviation on the intermediate deliverables prepared by the different cohorts

<table>
<thead>
<tr>
<th>Phase</th>
<th>Cohort #1 (N = 16)</th>
<th>Cohort #2 (N = 17)</th>
<th>Cohort #3 (N = 14)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M</td>
<td>SD</td>
<td>M</td>
</tr>
<tr>
<td>Analysis</td>
<td>4.69</td>
<td>0.48</td>
<td>4.76</td>
</tr>
<tr>
<td>Design</td>
<td>4.38</td>
<td>0.50</td>
<td>4.50</td>
</tr>
<tr>
<td>Develop</td>
<td>4.13</td>
<td>0.34</td>
<td>4.38</td>
</tr>
<tr>
<td>Implement</td>
<td>4.31</td>
<td>0.48</td>
<td>4.71</td>
</tr>
<tr>
<td>Evaluate</td>
<td>4.25</td>
<td>0.45</td>
<td>4.50</td>
</tr>
<tr>
<td>Total</td>
<td>4.35</td>
<td>0.30</td>
<td>4.57</td>
</tr>
</tbody>
</table>

Finally, we can notice that during the development and evaluation phases the lowest scores were achieved across all cohorts. This can be possibly explained by the fact that these phases require the usage of technical tools (namely, TinyMCE and ATutor) for the development of accessible web-based educational resources, as well as for the evaluation of their accessibility. This process requires technical skills and it might have been tricky for our sample taking into account that they were moderately experienced in using ICT.

Conclusions and future work

Within the landscape of the inclusive education, teachers are recognized as key players in supporting the process of leading to inclusive educational systems. As a result, teachers need to be equipped with appropriate competences for addressing the diverse needs and preferences of their students and providing them with equal educational opportunities. In this paper, we presented the design, implementation and evaluation of a teacher PDP for supporting teachers in the process of designing inclusive learning experiences for their students. The design of the teacher PDP was based on applying UDL principles for designing inclusive OERs. Moreover, the teacher PDP was aligned to support the competences as proposed by CFIT. The evaluation results of the teacher PDP showed that participants demonstrated a considerable amount of growth between pre-test and post-test when designing an inclusive lesson plan. Finally, participants' scores to the assessment activity of the teacher PDP were considerably high and within the excellent performance level. In conclusion, the lessons learnt from this study were that: (a) training on the application of the UDL principles should be associated and contextualized within the phases of the ADDIE model, so as to facilitate more efficiently teachers to design, develop and evaluate inclusive lesson plans for their students and (b) the proficiency level of teachers’ ICT competences might affect their performance to the development and evaluation phases of the ADDIE model, namely when developing and evaluating their inclusive lesson plans since these phases require the usage of technical tools (namely, TinyMCE and ATutor) for the development of accessible web-based educational resources, as well as for the evaluation of their accessibility. The results of our study could be useful for PDP designers, in order to design and develop effective teacher PDPs in the area of technology-supported inclusive education, as well as for appropriately implementing them towards achieving increased learning outcomes. Future research will include: (a) semi-structured interviews with the participants in order to gain qualitative feedback and reflections on the proposed teacher PDP's design and delivery and (b) longitudinal studies with the participants of the teacher PDP, so as to analyze the impact of their acquired competences via the teacher PDP to their teaching practice.

Acknowledgements

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References


Internet Use and Cybersecurity Concerns of Individuals with Visual Impairments

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*Corresponding author

ABSTRACT

Twenty individuals with visual impairments were surveyed in order to (a) understand their Internet use and (b) examine relations between metrics related to Internet use and cybersecurity-related knowledge, skills, confidence, and attitudes. Participants used the Internet for various purposes, including information search, communication, chatting, shopping, socialization, and education. The latter was more prevalent than in past research. Participants who were more knowledgeable and skilled regarding cybersecurity tended to be more concerned about it and to use the Internet less than those who were less knowledgeable about cybersecurity. Thus, cybersecurity concerns may lead individuals with visual impairments to decrease their Internet use, which could widen the digital divide.

Keywords
Accessibility, Internet use, Individuals with visual impairments, Disabilities, Cybersecurity

Introduction

According to the 2012 National Health Interview Survey, about nine percent (21.5 million) of the adult population in the U.S. had some kind of visual impairment. The American Printing House for the Blind (2012) reported that there were over 500,000 children who were blind in the United States. In addition to the congenitally blind population, the number of people with adventitious blindness, people who have lost their vision later in life, is also significant. For instance, the Blinded Veterans Association (http://www.bva.org) reports that around 7,000 veterans in the United States are vulnerable to lose their vision and become blind or visually impaired each year in addition to about 165,000 who are already blind or visually impaired. According to the 2012 Disability Status Report, about 24.6% of people who are blind or visually impaired are employed full-time (Erickson, Lee, & von Schrader, 2014). Given the fact that most corporations conduct their daily business affairs online through computers and the Internet, it is vital to educate people who are visually impaired in the use of computers at home and/or work.

The Internet and assistive technology can help people with disabilities maximize their potential and achieve personal, professional, and educational objectives (Brady, Morris, Zhong, White, & Bigham, 2013; Hersh, & Johnson, 2010). Basically, these technologies allow them to have access to information, work independently, execute errands such as shopping, participate in education and training, and communicate and socialize with others (Ari & Inan, 2010; Asuncion et al., 2012; Barile, Fichten, & Asuncion, 2012; Koustriva & Papadopoulos, 2014; Shuster, 2002). There are various challenges that Internet users who are visually impaired experience when surfing the Web, including cybersecurity concerns and accessibility issues (Domingo, 2012; Olalere & Lazar, 2011; Vigo & Brajnik, 2011). Even though a great number of preventative measures have been taken to make technologies, and in particular the Internet, more accessible, users with visual impairments still may have safety concerns when navigating the Internet. It is apparent that fear of cyber-attacks and exposure of sensitive information as well as limited accessibility of the Internet and its features hinder the benefit that users with visual impairments may enjoy.

Cyber-attacks are the primary concern, threatening the U.S. infrastructure, economy, and civilian’s safety. The Internet Security Threat Report published by Symantec Inc. (2014) shows an overall 91% increase in targeted attacks and 62% increase in the number of breaches in 2013. It is alarmingly a major concern that over 552 million identities were exposed and about 38% of mobile users have experienced mobile cybercrime in the same year. The estimation of the annual cost of cybercrime to the global economy is more than $400 billion (McAfee, Inc., 2014). The increasing number of cyber-crime incidents occurring in cyber-space raises the alarm and need for better protection and guards for individuals and, in particular, those with visual impairments.
Internet use by individuals who are visually impaired

Individuals with a disability could utilize various Internet services for banking, shopping, training, and social networking. Previous studies indicated that Internet use for communication (e.g., email) was the most commonly observed activity among individuals with visual impairments (Kaye, 2000). Surfing on the Internet for fun, listening to music, and social media involvement were among the other most frequently identified Internet activities (Kaye, 2000; Kelly & Wolff, 2012). Although it was not common, the use of the Internet for banking, shopping, and educational purposes was also found to be substantial (Ari & Inan, 2010; Kaye, 2000). However, findings from previous studies suggest that people with visual impairments tend to use computers and the Internet at rates below the average for the general population, indicating that a major digital divide still exists for users who are visually impaired (Kelly & Smith, 2008). Dobransky and Hargittai (2006) found that people with disabilities are less likely to use computers and are less likely to be online. According to a U.S. Department of Commerce report (2013), Internet use in the U.S. among households with people with a disability is only 48% compared to 76% for households with people with no disability. Similarly, a recent Oxford Internet Institute 2013 report from the United Kingdom presented similar findings that indicate that only 51% of people with a disability use the Internet, which is considerably less than the 84% of non-disabled respondents who use the Internet (Dutton & Blank, 2013).

In order to allow easy access to the Internet, there are a number of free Web browsers that are specifically designed for users who are blind (Bigham, Prince, & Ladner, 2008; Borodin, Mahmud, Ramakrishnan, & Stent, 2007). The use of assistive technology integrated with these Web browsers enables Internet users who are visually impaired to navigate and access the Web more easily. In addition to these accessible Web browsers, a number of free and commercial screen readers are also available to users with a visual disability (Department of Human Services, 2014). Although screen readers enable accessibility to the content, they may not always be usable. Lazar et al. (2007) listed the top five causes of frustration faced by users when using screen readers: (a) confusing layout; (b) technical conflicts between the screen readers and applications; (c) poorly designed forms; (d) no alternate text for images; and (e) inaccessibility to PDF files. Most screen readers have other limitations such as text-based presentation, linear access to information, inaccessibility of visual objects, loss of contexts, and repetition of reading (Chandrashekar, 2010). In addition, realization of the content structure of a Web page is extremely hard for a person who is visually impaired. For example, identifying specific information inside a table is one of the most difficult tasks for someone visually impaired (Gunderson & Mendelson, 1997; Murphy, Kuber, McAllister, Strain, & Yu, 2008).

Internet users who are visually impaired are more vulnerable to cyber-attacks due to absence or limitation of visual cues, inaccessibility of visual cues, and lack of software support to inform the users about the potential cybersecurity threats. In addition to challenges due to design of Web pages, there are other security challenges that users who are blind confront when surfing the Web, including the use of CAPTCHA, login sessions and timeouts, security updates, malware, and phishing (Holman, Lazar, & Feng, 2008). There have been some efforts to make CAPTCHA more accessible for users who are blind, using integration of sonification and sound with CAPTCHA (Lazar et al., 2012; Shirali-Shahreza & Shirali-Shahreza, 2011). Similar attempts have been made to improve users’ browser interaction through use of sonification techniques (Morley, Petrie, O’Neill, & McNally, 1999; Petrucci et al., 2000). However, these efforts are far below the expectations to meet the actual needs of individuals with visual impairments.

Definitions

Cybersecurity Threats: Any potentially harmful processes and actions performed to (1) access and use private information (e.g., identity theft), (2) attempt to deceive and scam users (e.g., spam emails), (3) install software intended to perform an unauthorized process (e.g., viruses & malware), or (4) directly attack computer systems and networks (e.g., hacking).

Individuals with Visual Impairments: Individuals who are functionally blind or have low vision who may use screen reader programs to carry out computing tasks.

Screen Readers: Specially designed software programs which convert text displayed on the computing device screen to audible text.
Cybersecurity Skills: Individuals’ ability to perform required tasks to secure computing devices and to manage cyber security threats.

Cybersecurity Confidence: Individuals’ perceptions about their own skills, knowledge, and capabilities to accomplish specific tasks to deal with cybersecurity issues.

Cybersecurity Knowledge: Individuals’ awareness and understanding of cybersecurity issues and risks associated with cyber threats.

Attitudes toward Cybersecurity Threats: Individuals’ intrinsic feelings of distress and discomfort due to cybersecurity concerns.

**Purpose of the study**

This manuscript reports the results of a survey conducted with twenty individuals who are visually impaired. The purpose of this study was to investigate the use of the Internet by individuals who are visually impaired and explore their cybersecurity challenges and concerns while surfing the Internet. Findings of this study will help to identify the major concerns and challenges of this group of Internet users and determine their assistive technology needs.

More specifically, the following research questions were addressed:
- What types of assistive technologies and software tools are used by individuals with visual impairments?
- What types of Internet and social media activities are carried out by individuals with visual impairments?
- What types of cybersecurity concerns do individuals with visual impairments have while browsing the Internet?
- Is there any common pattern between the types of Internet activities, cybersecurity concerns, and individuals’ cybersecurity knowledge, skills, confidence and attitudes?

**Methodology**

**Participants**

The participants of this study were twenty individuals with visual impairments over the age of 18. The participants were recruited through a special purpose school serving students who are blind or visually impaired (n = 7) and an adult rehabilitation center (n = 13) in Texas. The questionnaires were directly administered to each of the participant by a trained research assistant. The majority of participants were individuals who were blind (90%) and about half of the participants were female (45%). The range of participants’ ages was between 20 and 59 years old. Most participants (60%) were employed. In terms of ethnicity, the largest portion of the participants was white (65%). Table 1 presents the demographics and background characteristics of the participants in more detail.

<table>
<thead>
<tr>
<th>Table 1. Participants’ demographic characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
</tr>
<tr>
<td>Female</td>
</tr>
<tr>
<td>Male</td>
</tr>
<tr>
<td>Age</td>
</tr>
<tr>
<td>19 years or younger</td>
</tr>
<tr>
<td>20 - 29 years</td>
</tr>
<tr>
<td>30 - 39 years</td>
</tr>
<tr>
<td>40 - 49 years</td>
</tr>
<tr>
<td>50 - 59 years</td>
</tr>
<tr>
<td>Ethnicity</td>
</tr>
<tr>
<td>Black / African American</td>
</tr>
<tr>
<td>Caucasian / White</td>
</tr>
</tbody>
</table>
Hispanic / Latino

<table>
<thead>
<tr>
<th>Education level</th>
<th>6</th>
<th>30</th>
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<tbody>
<tr>
<td>Did not complete High School</td>
<td>2</td>
<td>10</td>
</tr>
<tr>
<td>High School/GED</td>
<td>8</td>
<td>40</td>
</tr>
<tr>
<td>4-Year College/Bachelor’s Degree(BA, BS)</td>
<td>8</td>
<td>40</td>
</tr>
<tr>
<td>Master’s Degree</td>
<td>2</td>
<td>10</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Types of visual impairments</th>
<th>18</th>
<th>90</th>
</tr>
</thead>
<tbody>
<tr>
<td>Person who is blind</td>
<td>2</td>
<td>10</td>
</tr>
<tr>
<td>Person with low vision</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Currently employed</th>
<th>12</th>
<th>60</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>8</td>
<td>40</td>
</tr>
<tr>
<td>No</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Data collection instruments

A survey investigating the cybersecurity concerns of individuals with visual impairments was developed and used for data collection. The survey consisted of four major sections: (1) demographics and background (2) technology/Internet use, (3) cybersecurity threats and concerns, and (4) cybersecurity knowledge, attitudes, beliefs, and confidence. The first section of the survey consisted of several demographic and background questions (e.g., gender, age, education, and employment status). The second part included a set of questions tailored to gather information about participants’ Internet use and experiences. The third section included items to gather cybersecurity concerns of participants while using the Internet. The fourth section was made up of four sub-scales with 24 items regarding participants’ cybersecurity knowledge and skills, attitude, and confidence. The majority of the items were created by a team of researchers including experts from special education, instructional technology, psychology, and computer science fields. The survey development was based on previous research and other data collection instruments (c.f., Ari & Inan, 2010; Asuncion et al., 2012; Lazar et al., 2007; National Cyber Security Alliance, 2010, 2011, 2012; WebAIM, 2014). Specifically, a section about social media was adapted from Asuncion et al. (2012) with the permission of the authors. In order to build an accessible instrument, survey design guidelines for persons who are visually impaired proposed by Kaczmarek & Wolff (2007) were followed.

Procedures

The data collection procedures began once potential participants were identified through professional networking and other recruitment methods. Participants were contacted via telephone or email, and a meeting time and location was scheduled. Participants either read a consent form prior to meeting or had the form read to them before the interview, at which point the participant signed the consent form. Interview questions were read aloud and multiple choice answers were marked by the research assistant interviewer. The open-ended questions were read aloud, and the participants’ answers were written verbatim. Following each interview, the interviewer input the answers into an online survey form that was submitted to the researchers at Texas Tech University. Interviewee questions about the survey were written verbatim, as were any requests for clarification and the verbal clarification that followed. This material and any other discussion material was typed into a field notes document that was shared with the researchers.

Results

Computing devices and assistive equipment

The results indicated that the participants were using a variety of assistive technologies, computing devices, and software applications. Laptops and smartphones were the most commonly reported devices by 90% of the participants. In regard to operating systems on computing devices, MS windows on laptop/desktop and iOS on smartphone/tablet devices were the dominant options. JAWs on desktop/laptops and Voiceover on
smartphone/tablets were the primary screen reader applications used. Additionally, diverse assistive technology devices were used with braille embossers, screen readers, optical character recognition, and voice recognition being the most commonly used tools. Table 2 presents the frequency of assistive and computing devices used by the participants.

Table 2. Use of computing devices, software, and assistive technologies

<table>
<thead>
<tr>
<th>Ownership of computing devices</th>
<th>N</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Desktop computer</td>
<td>13</td>
<td>65</td>
</tr>
<tr>
<td>Laptop computer</td>
<td>19</td>
<td>95</td>
</tr>
<tr>
<td>Tablet</td>
<td>9</td>
<td>45</td>
</tr>
<tr>
<td>Smartphone</td>
<td>19</td>
<td>95</td>
</tr>
<tr>
<td>Operating system on laptop/desktop computer</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Windows</td>
<td>20</td>
<td>100</td>
</tr>
<tr>
<td>Apple/Mac</td>
<td>2</td>
<td>10</td>
</tr>
<tr>
<td>Unix/Linux</td>
<td>3</td>
<td>15</td>
</tr>
<tr>
<td>Operating system on tablet or smartphone device</td>
<td></td>
<td></td>
</tr>
<tr>
<td>iOS (e.g., iPhone)</td>
<td>19</td>
<td>95</td>
</tr>
<tr>
<td>Android (e.g., Samsung Galaxy)</td>
<td>5</td>
<td>25</td>
</tr>
<tr>
<td>Windows (e.g., Nokia Lumia)</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>Screen reader program on desktops or laptops</td>
<td></td>
<td></td>
</tr>
<tr>
<td>JAWS</td>
<td>17</td>
<td>85</td>
</tr>
<tr>
<td>NVDA</td>
<td>2</td>
<td>10</td>
</tr>
<tr>
<td>Other (Multiple programs )</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>Screen reader program on tablets or smart phones</td>
<td></td>
<td></td>
</tr>
<tr>
<td>VoiceOver</td>
<td>15</td>
<td>75</td>
</tr>
<tr>
<td>TalkBack for Android</td>
<td>4</td>
<td>20</td>
</tr>
<tr>
<td>Other</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>Use of assistive technology Equipment</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Braille embosser</td>
<td>14</td>
<td>70</td>
</tr>
<tr>
<td>Screen reader</td>
<td>20</td>
<td>100</td>
</tr>
<tr>
<td>Braille notetaker</td>
<td>11</td>
<td>55</td>
</tr>
<tr>
<td>Refreshable braille display</td>
<td>9</td>
<td>45</td>
</tr>
<tr>
<td>Optical character recognition (OCR) software</td>
<td>14</td>
<td>70</td>
</tr>
<tr>
<td>Video magnifier</td>
<td>2</td>
<td>10</td>
</tr>
<tr>
<td>Magnification software</td>
<td>2</td>
<td>10</td>
</tr>
<tr>
<td>Voice recognition</td>
<td>14</td>
<td>70</td>
</tr>
</tbody>
</table>

Internet activities and social media

The survey data revealed that the most common activity was reading and writing emails as reported by 80% of the participants. Other common activities frequently or extensively performed by the participants included browsing the Internet for entertainment purposes (70%), downloading and uploading files (70%), and performing educational tasks (65%). In regard to the participants’ social media involvement within the past month, the most frequent activities included listening to a podcast (83.3%), using instant messaging services (77.8%), updating status on personal web spaces (77.8%), and adding someone to personal web spaces (77.8%). Table 3 and 4, and Figure 1 and 2 present the Internet and social media activities of participants.

Table 3. The frequencies of participants’ Internet activities

<table>
<thead>
<tr>
<th>Internet activity</th>
<th>NE (%)</th>
<th>R (%)</th>
<th>O (%)</th>
<th>F (%)</th>
<th>E (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Browsing Internet for fun (e.g., news, entertainment)</td>
<td>5</td>
<td>--</td>
<td>25.0</td>
<td>45.0</td>
<td>25.0</td>
</tr>
<tr>
<td>Reading and writing emails</td>
<td>--</td>
<td>--</td>
<td>20.0</td>
<td>45.0</td>
<td>35.0</td>
</tr>
<tr>
<td>Chatting &amp; instant messaging</td>
<td>20.0</td>
<td>25.0</td>
<td>20.0</td>
<td>25.0</td>
<td>10.0</td>
</tr>
<tr>
<td>Listening to music and/or watching videos</td>
<td>10.0</td>
<td>15.0</td>
<td>30.0</td>
<td>40.0</td>
<td>5.0</td>
</tr>
</tbody>
</table>
Social networking (Facebook, MySpace, Twitter, etc.) 15.0 5.0 35.0 30.0 15.0
Playing games 45.0 30.0 15.0 10.0
Formal or informal education (online courses, research) -- 10.0 25.0 35.0 30.0
Shopping 15.0 15.0 25.0 25.0 20.0
Banking 20.0 10.0 35.0 20.0 15.0
Making online payments 15.0 20.0 30.0 15.0 20.0
Downloading and uploading files 5.0 20.0 5.0 45.0 25.0

Note. NE = Never, R = Rarely, O = Occasionally, F = Frequently, E = Extensively.

Figure 1. Participants’ Internet activities

Table 4. Participant involvement in social media activities

<table>
<thead>
<tr>
<th>Activity</th>
<th>Yes</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Read a Twitter post</td>
<td>6</td>
<td>33.3</td>
</tr>
<tr>
<td>Replied to / shared someone’s Twitter post</td>
<td>5</td>
<td>27.8</td>
</tr>
<tr>
<td>Read a blog</td>
<td>11</td>
<td>61.1</td>
</tr>
<tr>
<td>Contributed to a blog</td>
<td>4</td>
<td>22.2</td>
</tr>
<tr>
<td>Listened to a podcast</td>
<td>15</td>
<td>83.3</td>
</tr>
<tr>
<td>Participated in multiplayer online gaming</td>
<td>3</td>
<td>16.7</td>
</tr>
<tr>
<td>Used MSN / Windows Live Messenger, Skype, Google Talk or another instant messaging service</td>
<td>14</td>
<td>77.8</td>
</tr>
<tr>
<td>Searched for someone on Facebook, MySpace, etc.</td>
<td>12</td>
<td>66.7</td>
</tr>
<tr>
<td>Uploaded a photo / video to Facebook, MySpace, etc.</td>
<td>4</td>
<td>22.2</td>
</tr>
<tr>
<td>Shared content (e.g., a link to a website) using Digg, Delicious, or another social bookmarking service</td>
<td>5</td>
<td>27.8</td>
</tr>
<tr>
<td>Updated your status on Facebook, MySpace, etc.</td>
<td>14</td>
<td>77.8</td>
</tr>
<tr>
<td>Added someone you know using Facebook, MySpace, etc.</td>
<td>14</td>
<td>77.8</td>
</tr>
<tr>
<td>Added someone you do not know / have never met before using Facebook, MySpace, etc.</td>
<td>5</td>
<td>27.8</td>
</tr>
<tr>
<td>Participated in web-based discussion forums</td>
<td>10</td>
<td>55.6</td>
</tr>
</tbody>
</table>
Problems and concerns while using the Internet

The survey results indicated that the participants often come across various problems/issues while browsing the Internet. The participants frequently experienced difficulty with security-related issues (e.g., misleading links) and other problems mainly due to the improper design of the Web pages (e.g., missing alt text descriptions). Table 5 and Figure 3 show the frequencies of problems participants experience while using the Internet.
Table 5. Frequencies of problems while using the Internet

<table>
<thead>
<tr>
<th>Problem</th>
<th>NE (%)</th>
<th>R (%)</th>
<th>O (%)</th>
<th>F (%)</th>
<th>E (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unwanted Pop-up</td>
<td>10.0</td>
<td>40.0</td>
<td>30.0</td>
<td>15.0</td>
<td>5.0</td>
</tr>
<tr>
<td>Misleading links</td>
<td>5.0</td>
<td>30.0</td>
<td>45.0</td>
<td>20.0</td>
<td>--</td>
</tr>
<tr>
<td>Spam emails</td>
<td>15.0</td>
<td>15.0</td>
<td>25.0</td>
<td>30.0</td>
<td>15.0</td>
</tr>
<tr>
<td>Security issues (e.g., viruses, unauthorized software)</td>
<td>35.0</td>
<td>45.0</td>
<td>15.0</td>
<td>5.0</td>
<td>--</td>
</tr>
<tr>
<td>CAPTCHA - image verification</td>
<td>15.0</td>
<td>10.0</td>
<td>45.0</td>
<td>20.0</td>
<td>10.0</td>
</tr>
<tr>
<td>Confusing page layout</td>
<td>--</td>
<td>25.0</td>
<td>35.0</td>
<td>40.0</td>
<td>--</td>
</tr>
<tr>
<td>Inaccessible Flash content</td>
<td>5.0</td>
<td>15.0</td>
<td>20.0</td>
<td>60.0</td>
<td>--</td>
</tr>
<tr>
<td>Complex or difficult forms</td>
<td>--</td>
<td>10.0</td>
<td>35.0</td>
<td>55.0</td>
<td>--</td>
</tr>
<tr>
<td>Images with missing alt text descriptions</td>
<td>--</td>
<td>10.0</td>
<td>10.0</td>
<td>70.0</td>
<td>10.0</td>
</tr>
<tr>
<td>Missing or improper headings</td>
<td>10.0</td>
<td>15.0</td>
<td>25.0</td>
<td>40.0</td>
<td>10.0</td>
</tr>
<tr>
<td>Automatic web page refreshing</td>
<td>--</td>
<td>15.0</td>
<td>45.0</td>
<td>40.0</td>
<td>--</td>
</tr>
</tbody>
</table>

Note. NE = Never, R = Rarely, O = Occasionally, F = Frequently, E = Extensively.

When asked about their cybersecurity threats and concerns, the majority of the participants (80%) reported their feeling as concerned or very concerned. In regard to specific issues, someone stealing private information (70%) or gaining access to financial information (65%) and personal information being made public (65%) received the highest concern rating while the possibility of a computing device getting infected with a virus or malware (35%) received the lowest rating. Table 6 and Figure 4 report the participants’ level of concern about the various issues while using the Internet.

![Figure 4. Participants’ cybersecurity concerns](image)

Table 6. Participants’ level of concern about the issues while using the Internet

<table>
<thead>
<tr>
<th>Issue</th>
<th>VC (%)</th>
<th>SC (%)</th>
<th>N (%)</th>
<th>SU (%)</th>
<th>VU (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Someone stealing your Identity</td>
<td>45.0</td>
<td>45.0</td>
<td>10.0</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Someone gaining access to your financial information</td>
<td>65.0</td>
<td>25.0</td>
<td>5.0</td>
<td>--</td>
<td>5.0</td>
</tr>
<tr>
<td>Someone stealing private information about you/your family</td>
<td>70.0</td>
<td>20.0</td>
<td>10.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Your personal information being made public</td>
<td>65.0</td>
<td>25.0</td>
<td>10.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Falling victim to an online scam or fraud</td>
<td>50.0</td>
<td>30.0</td>
<td>10.0</td>
<td>10.0</td>
<td></td>
</tr>
<tr>
<td>Someone tracking your online activities</td>
<td>40.0</td>
<td>55.0</td>
<td>5.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Someone hacking into your email</td>
<td>45.0</td>
<td>45.0</td>
<td>10.0</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Unintentionally installing malicious software 40.0 35.0 15.0 5.0 5.0
Your computing device infected with virus or malware 35.0 40.0 15.0 5.0 5.0

Note. VC = Very concerned; SC = Somewhat concerned; N = Neutral; SU = Somewhat unconcerned; VU = Very unconcerned.

Cybersecurity knowledge, skills, confidence, and attitudes

An examination of participants’ cybersecurity knowledge, skills, confidence, and attitudes indicated that the participants had moderate mean scores on these constructs ranging from 2.24 to 2.51. The Pearson correlation coefficients (Hinkle, Wiersma, & Jurs, 2003) were computed to investigate whether any correlation existed between these factors and the level of cybersecurity concern, frequency of internet activities, social media involvement, and frequency of internet problems/issues. Participants’ knowledge and skills had statistically significant negative correlations with level of cybersecurity concern ($r(20) = -.603, p < .01$ and $r(20) = -.500, p < .05$) and frequency of Internet activities ($r(20) = -.602, p < .01$ and $r(20) = -.515, p < .05$). On the other hand, frequency of Internet issues/problems was found to have a positive and statistically significant correlation with the frequency of internet activities ($r(18) = .523, p < .05$) and social media involvement ($r(18) = .640, p < .01$). The correlation coefficients, means, and standard deviations are shown in Table 7.

Table 7. Correlations, means, and standard deviations

<table>
<thead>
<tr>
<th>Variables</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cybersecurity Skills</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cybersecurity Knowledge</td>
<td>.808**</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cybersecurity Confidence</td>
<td>.777**</td>
<td>.773**</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Attitudes Toward Cybersecurity Threats **</td>
<td>-3.28</td>
<td>-2.44</td>
<td>-2.91</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Level Cybersecurity Concern ^</td>
<td>-6.03**</td>
<td>-5.00*</td>
<td>-4.37</td>
<td>.544*</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Frequency Of Internet Activities</td>
<td>-6.02**</td>
<td>-5.15**</td>
<td>-5.43*</td>
<td>.224</td>
<td>.239</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Social Media Involvement</td>
<td>-3.18</td>
<td>-2.04</td>
<td>-2.07</td>
<td>2.59</td>
<td>.182</td>
<td>.695**</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Frequency of Internet Issues and Problems</td>
<td>.118</td>
<td>.182</td>
<td>.018</td>
<td>-.167</td>
<td>-.245</td>
<td>.523*</td>
<td>.640**</td>
<td>1</td>
</tr>
<tr>
<td>Mean</td>
<td>2.24</td>
<td>2.39</td>
<td>2.51</td>
<td>2.51</td>
<td>1.69</td>
<td>3.26</td>
<td>6.78</td>
<td>3.07</td>
</tr>
<tr>
<td>SD</td>
<td>.63</td>
<td>.72</td>
<td>.79</td>
<td>.74</td>
<td>.52</td>
<td>.67</td>
<td>3.15</td>
<td>.56</td>
</tr>
</tbody>
</table>

Note. ^Lower score indicates positive attitude; **lower score indicates high level of concern. *Significant at the 0.05 level; **Significant at the 0.01 level.

Discussions

The purpose of this study was to explore Internet use by individuals with visual impairment. The study also explored participants’ concerns toward cybersecurity threats and relations between participants’ cybersecurity concerns and the frequency of Internet activities. In terms of Internet use, the results showed that various activities were being used by the individuals. Among those, email communication and browsing the Internet for fun/information were the most frequently reported activities. Previously conducted studies documented a similar pattern in regard to usage that individuals with visual impairment commonly use email for communication and interaction (Kaye, 2000; Kelly & Wolff, 2012). However, this study also revealed an increased use of the Internet for education purposes. This shift is probably due to the movement to provide more accessible educational opportunities for learners via online platforms (Pearson & Koppi, 2002; Seale, 2013; Seale & Cooper, 2010). Social networking and listening to music and other activities such as banking and shopping were also commonly reported Internet activities. Among those frequent social media uses were the use of social networking websites, podcasting, and instant messaging. This trend suggests that the extent of Internet usage was broad; individuals with visual impairments are exploring various new ways to use the Internet for communication, shopping, and socialization (Asuncion et al., 2012).

In regard to the Internet accessibility problems and security concerns while using the Internet, the results of this study revealed that critical issues were mainly related to the design of the websites (e.g., missing alternate text, complex forms, auto refreshing pages, etc.). Among those, the navigation structure and website organization were the commonly reported difficulties due to the lack of accessible design and the overwhelming amount of information.
presented on the web pages (Lazar et al., 2007). Such difficulties force individuals with visual impairments to spend an excessive amount of time to individually complete their intended tasks or to rely on other people for acquiring information or completing tasks. Webpages not meeting accessibility guidelines along with the difficulties related to security (e.g., unwanted pop-ups and misleading links) could easily result in user frustration (Lazar et al., 2007). Examination of user concerns showed that the majority of the cybersecurity threats received a serious concern rating. Among those concerns, the possibility of someone tracking their Internet activities was the highest-rated concern. These concerns related to security and privacy of personal information may keep many from engaging in online social activities and becoming online consumers. Reports from various organizations such Business Software Alliance and eMarketer indicated that about 60% of the U.S. population was affected by concerns about Internet security (Brant, 2009; Miller & Washington, 2006). Similarly, according to the UK Office of Fair Trading report, about 80% of web users were concerned about the security of their payment details when shopping online (Lomas, 2007). These concerns are probably higher for individuals with visual impairments as they do not receive sufficient cybersecurity feedback from browsers which may inhibit positive user experience (Wentz & Lazar, 2011). Therefore, it is important to guide the user in enabling security settings and to provide accessible software solutions to protect and warn the user who is visually impaired about cybersecurity threats while using the Internet.

Examination of participants’ data revealed that individuals have a moderate level of knowledge, confidence, and skill in cybersecurity. Furthermore, participants’ knowledge and skills were found to be related to their level of cybersecurity concerns, suggesting that when participants have a high level of cybersecurity knowledge and skills, their concerns were also high toward cybersecurity threats (Mohamed & Ahmad, 2012). Additionally, there were relationships between participants’ knowledge, skills, confidence, and frequency of Internet activities. However, the direction of the relationship was negative, suggesting that individuals with higher knowledge, skills, and confidence less frequently use the Internet for various activities. This result may be due to users having changed their behavior because of security concerns, as previous research found that users with security concerns are less likely to disclose personal information, buy goods, and bank online (European Commission, 2013). Media reports of mega breaches and major hacking instances may create public avoidance and a high degree of hesitancy toward Internet use for online shopping and online social networking (Riek, Böhme, & Moore, 2014). Although most people do not feel well-informed about the risks and protection from cyber threats (European Commission, 2013), they should be trained about proper security practices so that their behavior could be changed to enhance online security and make them feel more comfortable while using the Internet (McCrohan, Engel, & Harvey, 2010).

Future research should include the exploration and development of additional cybersecurity warnings for individuals who are blind or visually impaired to increase their degree of confidence in using the Internet. Collaborative research that includes software and commonly-used browser developers would enhance cybersecurity for individuals who are visually impaired on a broader basis if done from inception rather than after the fact. Including the end users with the disability in any such research is imperative. Hence, additional studies should focus on user-centric view of concerns associated with cybersecurity and should explore how these vulnerable users are reacting or responding to threats. The ongoing challenge for all accessibility issues is keeping up with the ever-changing technology and threats found on the Internet, but exploration of how to increase confidence of safety while using the Internet for individuals with visual impairment is greatly needed to provide equal access for this population.

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References


Social Networking as a Tool for Lifelong Learning with Orthopedically Impaired Learners

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ABSTRACT

This paper discusses how Turkish Cypriot orthopedically impaired learners who are living in North Cyprus use social networking as a tool for leisure and education, and to what extent they satisfy their personal development needs by means of these digital platforms. The case study described, conducted in North Cyprus in 2015 followed a qualitative research methodology: semi-structured interviews and document analysis were used for data collection. The study sample of 20 orthopedically impaired participants was selected from among members of the Cyprus Turkish Association for the Orthopedically Disabled which asked for volunteers. The study concluded that impaired learners typically satisfy their social and learning needs, or their need for excitement and relaxation, through social media. It is clear that the use of social networking only satisfies individual needs and does not contribute to group interdependence: if orthopedically impaired learners actively directed themselves to communicating more effectively among themselves and creating groups, they could solve personal problems through group solidarity. Social networks contribute to orthopedically impaired learners' lifelong education process: in addition to providing them with positive gratification, they also “informally” contribute to their personal education. Although the individuals who participated in this study do use social networks, more effort needs to be made within the context of North Cyprus to make use of social networks for formal education purposes.

Keywords

SNS, Lifelong learning, Orthopedically impaired, Technology, Cyprus

Introduction

In the context of human rights and lifelong learning, it can be said that social networking provide support for the development of the individual; and therefore that in the process of lifelong learning, equal opportunities should be provided for everyone to have access to social networks in their free time, for their personal development.

The main focus of this research is on the use of social networks as an educational tool by orthopedically impaired learners during their spare time in order to contribute to their personal development. The primary questions posed are:

- How do orthopedically impaired Turkish Cypriot learners living in North Cyprus use social networks as a tool of lifelong learning?
- To what extent do they satisfy their personal development needs by means of these digital platforms?

Theoretical framework

The theoretical framework of this study is based on lifelong learning, social networking sites, Uses and Gratification Theory, and the digital divide.

Lifelong learning

The view that people learn continuously throughout their lifetime is not new. The changes taking place in our daily lives, business lives, and science and technology, are occurring so rapidly that our information and skills constantly need to be renewed. It is very important that learning continues throughout one’s life, without being restricted to a specific time period or space (school), so that this continuity will enable the individual to adapt to life and become more qualified (Koç, 2005). Lifelong learning provides everyone with the opportunity to benefit from the concept of
an open school, but only by moving away from being available only to a restricted age group or from providing only restricted learning events; it is seen as offering a choice which enriches community life and gives individuals an opportunity to improve their potential (Demirel, 2003).

Otten and Ohana (2009) specified eight different areas in which individuals can improve their proficiency through lifelong learning: (1) Communication in the mother tongue; (2) Communication in foreign languages; (3) Mathematical competence and basic competences in science and technology; (4) Digital competence; (5) Learning to learn; (6) Social and civic competences; (7) Sense of initiative and entrepreneurship; and (8) Cultural awareness and expression. In addition, Greany (2003) emphasizes that lifelong learning should not be restricted to adult education and Aspin and Chapman (1997) point out that lifelong learning should not be seen as equivalent to technical skill-based education or arbitrary ways of learning something during daily life.

As Otten and Ohana (2009) indicate, technological competence and digital competence are very important aspects of lifelong learning. Van Weert and Kendall (2004), Inoue (2007), and Crawford and Irving (2013) also stress the use and importance of Information Communications Technology (ICT). That is to say, although technology is used in formal education, it is obvious that it has a very special significance in lifelong learning, which is based on ICT: more learners can benefit from education, commitment to an organization or a time-frame is decreased, and individuals learn at their own speed and can correct themselves.

The literature shows that in general, work done on behalf of the orthopedically impaired is directed towards formal education, and with the aim of supporting teaching (Maguire et al., 2006). This study differs from others in that it is focused on lifelong learning, and that in addition to considering mechanisms for supporting the period of teaching and learning, it is based on the idea of personal development within the framework of making use of leisure time; as Sivan and Ruskin (2000) point out, “Leisure is a basic human right, just as education, work and health are rights, and no one should be deprived of this right for reasons of gender, sexual orientation, age, race, religion, creed, health status, handicap or economic condition.” When human rights and the right to lifelong learning are taken into account, social networking sites (SNS) can provide valuable support for learners’ personal development. In addition, the earlier literature generally focused on ICT, whereas in this study, the focus is especially on detailing the orthopedically impaired individual’s habits and behaviors in using social media.

The orthopedically impaired and North Cyprus

The orthopedically impaired learners we studied within this diverse group were not mentally challenged; the condition of being orthopedically impaired can be defined as having one’s movements limited as a result of physical problems in the body’s skeletal structure.

In an interview, Günay Kibrit, the chairman of the “Cyprus Turkish Association for the Orthopedically Disabled,” stated that according to figures for 2015 from the North Cyprus, Office of Works, 4,996 is the official number of disabled people in the North Cyprus, of whom approximately 1,000 are orthopedically impaired. According to a population census carried out by the North Cyprus State Planning Organization, 286,257 people were permanently resident in the country in 2011. It is estimated that in 2015 this population will exceed 300,000.

Social networking sites

Social Networking Sites (SNS) are founded on a technology known as “Web 2.0.” According to Kaplan and Haenlein (2010), “Web 2.0 is a term that was first used in 2004 to describe a new way in which software developers and end-users started to utilize the World Wide Web; that is, as a platform whereby content and applications are no longer created and published by individuals, but instead are continuously modified by all users in a participatory and collaborative fashion” (pp. 60-61). When the Web 2.0 system began to be used by websites, the concept of User Generated Content (UGC) emerged. In this way, the users were placed in a position where they were not simply consumers, but also producers, able to share what they produced with a wide audience. Some examples of popular Web 2.0 based systems conducive to the creation of content by users are SixDegrees.com (1997), Myspace (2003), Facebook (2004), Youtube (2005) and Twitter (2006). Today, there is an increasing number, and an increasing
frequency of use, of sites which are typically referred to by users as “social networks” or “social media.” In 2015 the number of users of social networks is 1.96 billion; by 2018 this figure is expected to reach 2.44 billion.

Boyd and Ellison (2008) define social network sites as “web-based services that allow individuals to (1) construct a public or semi-public profile within a bounded system, (2) articulate a list of other users with whom they share a connection, and (3) view and traverse their list of connections and those made by others within the system. The nature and nomenclature of these connections may vary from site to site” (p. 211).

When social networks first emerged at the beginning of the 2000s, they gave individuals the possibility of creating a profile for themselves and making the acquaintance of other users (Ellison, Steinfield & Lampe, 2007; Lin & Lu, 2011, Kane et al., 2009). Since then, social networks have developed to such an extent that end-users are now filling them with their own content, and sharing everything from knowledge to news, from marketing to sales, from advertising to propaganda. In order to understand the attraction of social networks which bring so many people together, one must look at the results of research about the Internet conducted from the perspective of Uses and Gratification (U&G) theory.

Uses and gratification theory

The most important feature that attracts people to social networks more than to traditional media is that they are “interactive.” As Kaye and Johnson (2001) noted, internet users are more actively involved and engaged in using the Internet because of its interactivity. Uses and Gratification (U&G) theory has been making an important contribution to the literature on individuals’ use of social networks. According to Katz et al. (1973), this is based on the social and psychological origins of needs, which generate expectations of the mass media or other sources, which lead to differential patterns of media exposure, resulting in need gratifications and other consequences (pp. 510). They emphasize that U&G studies have two distinct approaches: evaluating how needs are gratified by media, and evaluating how gratifications reconstruct needs (Smock et al., 2011, p. 2323). According to Quan-Haase and Young (2010), “One of the more successful theoretical frameworks from which to examine questions of ‘how’ and ‘why’ individuals use media to satisfy particular needs has been the uses and gratifications (U&G) theory” (pp. 351).

U&G studies have two distinct approaches: one focusing on how needs are gratified by media, and the other on how gratifications reconstruct needs (Smock et al., 2011, pp. 2323). Severin and Tankard (2001) emphasize the psychological communication perspective in U&G theory, and point out that individuals can use mass communication tools for very different aims. Another purpose of U&G theory is to understand how mass communication tools are used by individuals to satisfy their needs, and to determine their positive and negative consequences. Ruggiero (2000), however, notes the following weaknesses of U&G theory: (i) media users may not know the reasons why they chose to use what they are using and may not be able to explain it clearly; (ii) the theory lacks internal consistency and theoretical justification and has weak predictive capabilities; and finally (iii) it is difficult to measure the gratification structure with the self-report data.

The role of SNS in orthopedically impaired learners’ life and digital divide

The “digital divide” refers to the gap created by access or lack of access to and the manner of use of technology by members of various social identity groups (Bolt & Crawford, 2000, pp. 39). The concept of the digital divide, which has been discussed since the middle of the 1990s, criticizes not only unequal access to technology between countries, but also unequal access among people living in the same country. The general literature on the subject tries to expose the factors creating a digital divide between the individual and society. At the top of the list of these factors are education (Latimer, 2009), employment (Uzunboylu & Tuncay, 2010), age (DiMaggio et al., 2004), culture (Drori & Jang, 2003), race and ethnicity (Hoffman & Novak, 1998), ethics (Hacker & Mason, 2003), internet skills (van Deursen & van Dijk, 2010), gender (Dixon et al., 2014), and rural-urban separation (LaRose et al., 2007). Thus, this divide reproduces the already extant inequalities between rich and poor, urban and rural, and an ethnic white majority and ethnic minorities (Dixon et al., 2014, pp. 991-992).
When the reasons behind the digital divide are examined, an individual’s being “disabled” must be seen as an important contributing factor. Disabled people experience relative inequality in their engagement with the Internet, in terms of their physical access to it as well as their use of digital technologies and network capability. Disabled people are more likely to experience structural inequalities such as not having educational qualifications, being outside work and living in deprived neighborhoods (Sourbati, 2012, pp. 577). Despite Van Dijck and Nieborg’s (2009) declaration that “all [Web 2.0] users are equally creative and are created equal” (pp. 860), it is first of all disabled individuals who are found to encounter obstacles in accessing the Internet and digital technology. The poor economic conditions of the disabled, low levels of education, and, related to this, their low level of skills in using computers, indicate the difficulties they experience in accessing the Internet and digital devices. Disabled citizens with weak financial resources struggle to buy electronic devices that can access the Internet, and even if they purchase a device, they do not become proficient in its use because of a lack of education. For this reason, as Hargittai and Walejko (2008) have pointed out, when disabled people make use of the Internet, they experience the problem of a “participation divide.”

We know that Internet use contributes positively to the quality of life of the disabled. Studies of disabled learners’ access to the Internet have prioritized such subjects as web accessibility (Adam & Kreps, 2006), societal inequalities (Van Dijk, 2005; Witte & Mannion, 2010), and the impact of information and communication technology (Guo et al., 2005; Dobransky & Hargittai, 2006; Warschauer, 2003; Luke, 2002; Wilding, 1999). These studies suggest that “computer and Internet technologies have the potential to help provide people with disabilities access to a myriad of professional, educational, social, and economic resources. In fact, according to research by the National Organization on Disability, the Internet is having a greater impact on the lives of adult Internet users with disabilities than on those of adult Internet users without disabilities” (Taylor, 2000, pp. 28).

In particular, in a developing country like North Cyprus, where orthopedically disabled learners experience distressing situations simply when going out on the streets, the Internet takes on a special importance in their lives. Because of the problems they experience as a consequence of their orthopedic disabilities — in getting an education, finding work, and having a social life — and in order to overcome them, they feel a need for the Internet and social networks. Guo et al. (2005) explain the benefits that the disabled gain for themselves by using the Internet as follows: “[disabled persons] have access to a common open space, helping them break down barriers that exist in the real world physical and social environments. Internet use in turn brings about more social interaction opportunities and higher levels of satisfaction with friendships, social participation and social support. This is particularly the case for more knowledgeable users, who are ready to make optimal use of the medium and its resources” (pp. 53).

There are examples in the literature of studies which indicate that disabled learners’ difficulties and problems in accessing Internet are proportionally greater than those encountered by the general population (Kaye, 2000). According to Lilley (2004), using ICT undoubtedly makes both school life and life in general easier for the orthopedically disabled, and on the whole has a positive effect. But it should be understood clearly that ICT cannot work miracles, and does not have the power to take away a disability. To make a real impact on the lives of the orthopedically challenged, even after choosing the right technology, takes a certain level of patience, effort, and awareness.

Method

This research is based on qualitative analysis: qualitative research patterns are taken as a basis for a detailed analysis of the use of social networking by orthopedically disabled learners in North Cyprus, studied through data collected from face-to-face interviews.

Participants

Participants were selected through a sample survey: orthopedically disabled members of the Cyprus Turkish Association for the Orthopedically Disabled were chosen to take part in the study. As it has the largest membership in North Cyprus, this association was brought into the scope of the research. When the participants were being selected, two distinct sampling methods were followed: easily accessible and maximum diversity sampling. Because of this,
the project first of all included physically disabled individuals who were frequently making appointments to visit the Association and undergoing treatments.

A basic condition of the research was that all twenty people within the sample had access to a computer and the Internet. The number of participants and the number of years they had used the Internet were as follows: 2 people had been on the Internet for 2-3 years, 5 people for 4-5 years, and the remaining 13 for 6 years. Participants’ hours of use of the internet per day were: 4 people for less than 1 hour, 7 people for two hours, and 9 for more than 3 hours. Finally, as regards their self-declared levels of competence in using the Internet: 3 people felt their competence was not adequate, 7 people said they were adequately proficient, and 10 people said they were at an advanced level.

**Data collection tools**

A “semi-structured feedback form” was used as a data collection tool. When this questionnaire on “Orthopedically disabled learners usage of internet and their activity in social networking” was prepared, special attention was paid to communicating effectively and productively, ensuring clarity of the questions; leaving space for the possibilities of detailed answers; and avoiding putting unnecessary pressure on the participants by asking multi-dimensional questions.

The feedback form was made up of four sections, and there was a total of 24 questions. The first section asked for the participants’ demographic information. In the second section, orthopedically disabled individuals were asked generally about their usage of the Internet (their habits). The third section asked questions to determine the participants’ use of social networks during their free time.

In preparing the feedback form, the researchers consulted five experts from the fields of communication, computer and teaching technologies, special needs education, linguistics, and quantification and evaluation. Questions were modified or omitted based on their opinions and suggestions. The form was then tested out on a pilot orthopedically disabled individual. This pilot trial lasted 30 minutes, and in view of the results, it was decided that alternative questions or cues were unnecessary for the purposes of this study.

**Procedure**

Verbal permission to conduct the research was first obtained from the Chair and Assistant Chair of the Association before starting to collect data. To ensure that participation was voluntary, before the interviews, permission was obtained from the interviewees themselves: the purpose of the interviews was explained; and it was made clear to them that they could stop the interview at any time and that after the interview if they had any reservations concerning what they had said, they could choose not to have their responses used in the study. It was also explained to the participants that for ethical reasons, their names would not be used in the research. The interviews were held during 2–13 February 2015, generally during working hours (08.00-16.00), in the Association’s library in Nicosia. Two researchers attended each interview together, and care was taken not to direct or lead the participants during the interviews. Individual interviews were held with the participants, (20 separate sessions): The interviews lasted an average of 30 minutes, and with participants’ permission they were audio recorded and notes were taken during the sessions. Finally, the recordings were transcribed, the notes were added, and the data set for the research was prepared for analysis.

**Data analysis**

The content of the data gathered from the interviews was analyzed. The interview questions were taken as the basis for the study, and themes were specified and interpreted. As the findings were presented, tables were used to elaborate on some themes. In order to ensure legitimacy and accuracy in the analysis, all data were written out in detail, so the conclusions would be clear and understandable. The researchers reduced the possibility of differences of opinion to the minimum by working together at every phase of the data analysis of the interviews. Finally, the
thoughts expressed by the interviewees were frequently used as quotations; and the research conclusions were presented from these directly.

Findings and results

Social networking usage in leisure time

In this part of the study, we measured the use of social networking by the participants, and also their level of satisfaction. The disabled participants who engage in a lot of activities in their spare time generally make frequent use of the Internet and social media. Because more than half of the learners we interviewed are not working, they have a lot of free time during the day. Also, since 14 of the 20 participants are single, they have fewer responsibilities in the home, and devote significant time to social networks. Of the participants, 65% had been connected to the Internet for more than six years, and 80% of them use the Internet for more than two hours a day. The level of proficiency of the orthopedically disabled in Internet use was seen to be 85% moderate \((n = 7)\) and high \((n = 10)\).

The purpose of using social networking

When we examine the purposes for which the orthopedically disabled in North Cyprus use social networks, we see that individuals may use them for different reasons. Broadly speaking, the main reasons are: spending free time, having fun, and obtaining information. Other reasons are: passing time, relieving stress, acquiring knowledge, doing research, resting, learning about the problems of other disabled people in the world, letting go, sharing, gaming, watching film series, reading newspapers, having a good time, relaxing, and chatting.

The disabled learners who have difficulties in getting out of the house spend a large amount of their free time on social networks. Participant 7 (Female, 47) said she uses social networks “to fill spare time and learn things.” Some responses from the participants’ explain why some social networks, and specifically Facebook, are preferred by disabled learners. Participant 4 (Female, 45) said: “We learn everything from Facebook: who’s not feeling well, who’s had a baby.” Facebook is preferred because it is easy to access information from it, and its focus on user-generated content makes it easy for people to share things with others. By enabling the sharing of feelings, writings, poems, videos, etc., it makes it possible for people to socialize, and also get feedback from around them. Participant 11 (Female, 60) explained what these features of Facebook offer to her: “I use it to chill out and discharge, and I share my poems. I pour my feelings into my poems and I share them. They get “likes,” and that makes me happy. I express my reactions to events in the community. It makes me happy when there’s interaction. I write out what’s inside me there, and I relax.”

Activities

An important point to consider is what kind of activities orthopedically disabled people engage in on social networks in their spare time, in particular as regards lifelong education. The participants explained their main activities and goals, which in general, for those who went onto social networks to occupy their free time, including listening to music, watching films, chatting, reading newspapers, doing research to acquire knowledge, and looking at recipes.

Participants in the age group which we can consider as “digital immigrant” (Prensky, 2001) spoke of how they were bored with some of the activities on social networks. Participant 7 (Female, 47), for example, said: “I read newspapers. I’ve forgotten how to write. Social media put an end to the smell of books. I read the news that I choose to read.” At the same time, Participant 11 (Female, 60) didn’t want to stay tied down to social networks: “I wish there was a place we could go, and not the Internet. Where we could go by ourselves. I want to be free.” And Participant 13 (Female, 38) said she was fed up with chatting on social networks, and would prefer instead to meet people face-to-face.
**Education**

From the results of our in-depth interviews, it appears that the participants did not use social networks very much in their spare time for educational purposes. While some of the participants said they used social networks to do research, acquire knowledge and read books, a large majority said they did not make use of online courses or education from social networks. Two participants who are continuing their studies at the master’s level said they use the web for academic purposes, to survey the literature in their fields. Participant 6 (Male, 47) said he used it to learn about work-out methods: “I use it to develop myself in the field of sports. I use it to find ways to work out in a wheelchair and analyze opposing teams.” Participant 7 (Female, 47) said she researched her illness, and so educated herself and became more knowledgeable. Participant 12 (Male, 23) said his aim in using social media was to educate himself, and that he was following new developments in desktop publishing: “I use it to do research. I watch programs on Photoshop and Corel Draw and then apply what I learn.”

**Effects and feelings**

**Effects**

In this section, the research focused on the effects of social networks on the daily lives of the orthopedically disabled, and the feelings they experienced when using them. The responses indicate that the participants felt that as long as social networks are used moderately, they can serve as a positive and useful platform. In addition, participants said that the most fundamental positive effect of social networks on their daily lives had been to provide them with opportunities for “socializing and fast, cheap communication.” Because social media make it possible to read others’ opinions and interpretations, these media have a positive effect on disabled learners’ emotions. Participant 2 (Male, 42) explained the special benefits he got from the interactivity of social networks: “I make a connection. It’s important for me. Because I want to communicate and because I am active, I have connections. They respond to my books and my writings. I read about the effects of my writing.” Participant 3 (Male, 39) emphasized the importance to him of the fact that with social networks you can follow things as they happen and find out what you want to know any time you choose.

From the responses it was clear that some of the disabled learners, in the “digital native” category in particular, didn’t want social networks to play too great a role in their daily lives. Participant 5 (Male, 47) said that for him social networks were not a must, but also commented that social networks contribute to personal growth: “[Social networks] do have an effect on my daily life. I use them to get feedback and criticism. You develop yourself through criticism. You question yourself.” Participant 11 (Female, 60) explained the effect of social networks on her daily life as follows: “There’s no place we can go and travel around. You need a car to go everywhere. So I have to be in my partner’s house. When he has time he takes me out. Where do people go all the time? We’re killing time in the house. That’s why we use social networks.” From this we can see that in the daily lives of some orthopedically disabled learners, social networking functions as a platform for filling empty hours. It is clear that they are forced to stay at home more and use the Internet more because of the deficiencies in North Cyprus’s architectural infrastructure and facilities for mobility.

Two of the participants raised an important point regarding dependence on social networks. Participant 13 (Female, 38) said we have to be careful when using social networks, so that we stay connected to real life: “I’m trying not to get hooked on it. So I didn’t get a smart phone. I have to be in real life. Let’s not lose our human feelings.” Participant 16 (Female, 26) said social networks were an “addiction” for her, that she was constantly wondering what was happening on the networks and that she couldn’t get by without using them.

**Feelings**

When we studied what the participants felt while using social networks, in general their responses indicated positive feelings. Emphasizing that social networks bring people who are far away closer, some users were excited and happy to be able to fulfill their wish to be with relatives who were far away. Some described the feelings they got from social networking as joy, laughter, cheerfulness and pleasure. The effects of social networking on the feelings of the orthopedically disabled subjects of the study are shown in Table 1.
Table 1 illustrates the wide range of feelings experienced by the orthopedically disabled when they are using social networks. These reveal the satisfaction provided to these individuals by the networks. It can also be seen that social networks are both a need and a necessity for the disabled. Due to the fact that they provide happiness, pleasure, excitement, a feeling of security, and many other different feelings, social networks play an important role in filling free time for the orthopedically disabled. Participant 7 (Female, 47) said that social networks provide a sense of safety for her as a disabled person: “When I go to places, I constantly check to see if there’s wireless internet. You feel that you’re more secure, you get the strength of knowing ‘I can reach everything’.” The feeling of safety is especially important for orthopedically disabled people who need assistance from others. This means that in future the disabled will make more use of social networks to be able to reach the person they want when they want, not only because of the ease, but also because of the speed with which one can ask for help.

<table>
<thead>
<tr>
<th>Participants</th>
<th>Feelings</th>
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<tbody>
<tr>
<td>Participant 1 (Female, 39)</td>
<td>“I feel happy. When they’re not there I feel empty. Like when Facebook was down for a few days.... there was a problem with the telephone.”</td>
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<tr>
<td>Participant 2 (Male, 42)</td>
<td>“Depending on your mood at the time, you can experience anything.”</td>
</tr>
<tr>
<td>Participant 3 (Male, 39)</td>
<td>“It’s really exciting and I like it. It’s a great communication tool. It’s exhilarating when you use it to do what you want.”</td>
</tr>
<tr>
<td>Participant 5 (Male, 47)</td>
<td>“There’s a sense of satisfaction. You share, and when you read the comments you get a feeling of satisfaction. You believe you did something right. We question our own inner worlds. We criticize.”</td>
</tr>
<tr>
<td>Participant 7 (Female, 47)</td>
<td>“There’s definitely a great emptiness [when there’s no Internet]. When I go to places, I constantly check to see if there’s wireless internet. You feel that you’re more secure, you get the strength of knowing ‘I can reach everything’.”</td>
</tr>
<tr>
<td>Participant 11 (Female, 60)</td>
<td>“You go into a completely different world; your mind changes. I forget the things that bother me. I get rid of stress, and I become happy. When I write, expressing myself and my feelings, and then think back, it seems like I’ve raised awareness [about the disabled]. I become happy when I write down my feelings.”</td>
</tr>
<tr>
<td>Participant 13 (Female, 38)</td>
<td>“I don’t get very emotional. I try not to get carried away. I don’t get jealous.”</td>
</tr>
</tbody>
</table>

Problems

The orthopedically disabled participants who were “digital natives” indicated that they didn’t experience many problems when using the Internet in their spare time. These individuals complained more about deficiencies in the technological infrastructure and the slow speed of the Internet. However, disabled “digital immigrant” users spoke of the skills needed to use the technology, their lack of knowledge, and their need for education. While Participant 6 (Male, 47) said “I have problems because of the skills needed to use this,” Participant 4 (Female, 45) complained about the impatience of the people she tried to get help from: “I want help from my children but I can’t get the help I need. The children are impatient. When we don’t understand things they don’t want to explain them to us again. They say ‘we showed you that before’.” Participant 9 (Female, 50) had similar problems: “I’m having problems using technology. I get help from my children, but they explain things quickly and we don’t understand.” It is clear that when disabled people have problems using the Internet, the people who are closest to them, their family members come to their help. But because of the impatience and rapid explanations they get on how to solve problems from the people whom they are supposed to be getting help from, this isn’t always helpful. On the other hand, Participant 7 (Female, 47) said she was trained to use the technology for three months by a cousin: “When I’m using [the Internet], I have problems. I have a cousin who’s an expert. He taught me for three months. They grew up with these devices.” The comment that “They grew up with these devices” shows that the problems arise for people who weren’t born into the technology. From the responses we received, it can be seen that in the “digital native” category, orthopedically disabled learners aged 40 and above are lacking the knowledge to use the Internet and social networks. In addition, because these individuals’ skills in using electronic devices are weak, it is clear that that have
to be given short-term training and education in order for social networks to contribute more to filling their spare time, to making their lives easier, and to not add more obstacles to those that already exist. Educational issues such as digital literacy, social media literacy and Internet use have to be worked on and the problems people are experiencing have to be addressed.

Conclusions

In this study, we researched the behaviors of orthopedically disabled learners, focusing on their use of social networks as part of their lifelong educational development goals. According to their own accounts, their habits with respect to social networks are determined by their aims. In general, disabled learners who use social networks do so in order to pass time, listen to music, watch films, chat, read newspapers, research to learn new things, and look at recipes. Even if they do not use social networks directly for educational purposes, they still learn from them. Heo and Lee (2013) define this kind of learning from social networks as “non-formal” education. In such non-formal learning media, user-generated content can be shared with ease. Sharing in social networks, and interactivity with comments and replies, have a positive effect on disabled learners’ sense of socialization, education and general culture.

Social networks contribute in lifelong education to the personal development of orthopedically disabled learners; Dincyürek et al. (2011) confirm that additional usage of computers by the orthopedically challenged contributes to their development and to improvement of their conditions. Social networks not only provide gratification to the orthopedically disabled in a positive way; they also contribute “informally” to their education. There is no doubt that awareness needs to be increased of the importance of social networks in raising knowledge levels and providing personal development as part of lifelong learning. And although the people interviewed in this study used social networks, more work has to be done in North Cyprus on the subject of more effective usage in the context of formal education.

It can be concluded from the responses received that disabled learners use social networks to satisfy their needs for socialisation, learning, excitement, and relaxation. Through applying Uses and Gratification Theory, Parker and Plank (2000) and Tan (1985) demonstrated that such individual needs were satisfied by the media. Of course, this process has evolved as social networks have come to be used more and more in the daily lives of individuals. Individuals are no longer simply passive “consumers” of media for their needs; now, through the user-generated content features of social networks they have become active “producers.” This active process has led to a positive transformation in terms of usage of social networks and gratification, for orthopedically disabled people, who spend most of their time at home. Dobransky and Hargittai (2006) explain this positive effect as follows: “In much the way that medical and other forms of assistive technology have improved the physical functioning of people with disabilities, ICTs have been viewed as tools that enable people with disabilities to escape the isolation and stigma that sometimes accompany their disabilities” (pp. 315).

Yet in spite this, it can be said that for the orthopedically disabled, social networks are limited to satisfying individual needs, and do not fulfill the need for group cooperation and gratification; if the orthopedically disabled in North Cyprus focused on forming groups, personal problems could be resolved through group solidarity. It can be said that the architectural and public circulation deficiencies in the country also force the orthopedically disabled to stay home and use the Internet more. Digital immigrants who participated in the study did not want to be dependent on social networks, and expressed a preference for socializing in person, face-to-face, in different spaces. In addition, they did not want to be affected too much in their daily lives by social networks.

While this study shows that orthopedically disabled digital natives do not encounter many problems while using the Internet during their free time, disabled digital immigrants spoke of their need for education because of their lack of technological skills and knowledge. When they encounter a problem with using the Internet, the people who are closest to them, their family members, come to their help.

Orthopedically disabled learners believe that because of their disabilities and their inability to go out often, they become more dependent on the Internet and social networks, and spend more time on social networks in their free time. The fact that they do not have professions (are unemployed), or that if they became disabled later in life, they cannot continue in their professions, determines how frequently they visit the Internet and what sites they visit. Many say that if they had been working, they would have had less free time, and that the Internet sites they visit would
have been related to their professions. They also stress that if they were not disabled, they would have gone out more, traveled, gone to school or work, visited their friends, or gone out to a cafe or cinema.

In North Cyprus, a great many orthopedically disabled learners are unable to get an education and remain unemployed as a result of their disability. For this reason, they feel a need to be educated in digital literacy. In addition, especially among the older digital immigrants, orthopedically disabled learners have problems with skills in using computers and social networks. There is a need for educational programs for such disabled learners, who do not feel adequate in these areas.

References


Standardization of a Graphic Symbol System as an Alternative Communication Tool for Turkish

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ABSTRACT

Graphic symbols are commonly used across countries in order to support individuals with communicative deficiency. The literature review revealed the absence of such a system for Turkish socio-cultural context. In this study, the aim was to develop a symbol system appropriate for the Turkish socio-cultural context. The process began with studies designed to delineate the scope of the proposed system. Firstly, a dictionary was formed, founded on the literature. In the following stage, a visual design form was developed with a view to identifying visual representations of these words. Using this form, 106 participants were asked for their opinion. The data collected were examined, and common traits of the graphic(s) indicated for each word were identified so that alternative graphic(s) could be prepared accordingly. From one to five visual representations were identified for each word and the corresponding graphic symbols were drawn in electronic media. An e-measure was developed in order to find out whether these graphics were sufficient to represent the corresponding objects, concepts, or situations. The scale was sent to participant groups across Turkey to obtain the opinions of individuals from divergent age, culture, and educational backgrounds. A total of 1,099 participants were asked for their opinion. This resulted in a new system consisting of standard graphic symbol(s) for 843 words and seven forms of affix structures appropriate for writing Turkish using graphic symbols.

Keywords

Turkish, Alternative communication, Graphic symbol system, Deficiency

Introduction

Writing is a crucial means of communication. Emotions, beliefs, comments, experiences, and knowledge can be expressed and shared with other people, organizations, or wider populations via writing (Gnanadesikan, 2009). Writing systems are divided into four categories: pictographic, hieroglyphic, cuneiform, and alphabetical. Most writing systems were originally pictographic, that is, symbols were used to represent words and ideas. However, symbols started to be used for sounds instead of concepts since such symbols gradually became less useful and new symbols were needed for every word. In the course of time, symbols became more stylized and less representative and thus they evolved from one to another (Coulmas, 2003; Lunde, 2009).

The literature review shows that many countries use graphic symbol sets/systems to support the communication and learning capacities of individuals with speech, learning, and linguistic deficiencies (Volpato, Orton, & Blackburn, 1985; Carmeli, & Shen, 1998; Whittle, & Detheridge, 2001; Alant, Life, & Harty, 2005; Brown, 2006; Parette, Boeckmann, & Hourcade, 2008; Zainuddin, Zaman, & Ahmad, 2009).

The literature provides many studies referring to graphic symbols used in learning and assessment of individuals whose expressive or receptive linguistic skills are not sufficiently developed (Heller, Ware, Allgood, & Castelle, 1994; Trudeau, Sutton, Dagenais, De Broeck, & Morford, 2007; AlJa’am, ElSeoud, Edwards, Ruiz, & Jaoua, 2009; Emms, & Gardner, 2010; Bunning, Kwiatkowska, & Weldin, 2012). Researchers, young children, individuals, and people in general are seeking an answer to the question: “Is it possible to obtain more accurate and detailed information by means of a pictorial scale?” (Harter, & Pike, 1984; Valla, Bergeron, & Smolla, 2000; Reid, Vallerand, Poulin, & Crocker, 2009).

Graphic symbols are considered as alternative means of communication for most individuals who are not able to speak to communicate the need special education. They may also be regarded as materials stimulating visual intelligence for enriching learning environments for individuals showing normal development. In order to investigate whether or not graphic symbols can be used as a means of learning or communication, a lot of studies were carried out on different populations with and without any disability.
As an example, Cohen, Allgood, Heller and Castelle (2001) researched the effects of picture dictionaries on expressive communication skills of professional training students with auditory and mental problems. In the study which aimed at regulating the communications of students with their peers, manager and others in the work environment, customized picture dictionaries were devised which contain symbols and corresponding words or terms for individual participants. The dictionaries were configured by using black-and-white PCS symbols. Research results revealed that students could effectively utilize the picture dictionaries for expressing themselves. It was understood that students preferred picture dictionaries to take notes in most cases though all means of communication were available.

As another research in this area, Visser (2006) examined a group of children aged 4 with normal development to find out their ability to recognize basic emotions expressed with graphic symbols. For four basic emotional status such as happy, upset and angry, 4 corresponding symbols were selected by a group of experts from the PCS, Picstems and Makaton sets/systems. The participants responded 3 questions regarding each emotion by indicating the target symbol out of 16 random symbols on one page. It was found out that participants could recognize feelings transmitted with graphic symbols.

Trudeau et al. (2007) investigated how graphic symbol expression is affected from syntactic complexity. Study participants consisted of French-speaking individuals with not communicative problem. They were divided into 3 groups of 30 each according to their mean age (7, 13 and 27). A special software (Widgit 2000) was installed so that a medium could be designed to produce expressions representing human beings, objects and movements illustrated in photos. The photos and prompts were given to participants who were then instructed to produce suitable sentences by using the graphic symbol medium. The study was found to be approximately 100% effective in producing simple expressions for almost all age groups. Yet, diversity of the symbol combinations for more complex expressions decreased almost by half the success of the children. Among teenagers and adults, the graphic symbols proved useful above 70% for expressing complex sentences.

Nigam and Karlan (1994) aimed to develop PCS symbols suitable for Indian children and youngsters and to ensure the validity of them. They argue that graphic symbols mostly address the cultural/ethnic context of the USA and Europe, and that there are few studies investigating whether symbol sets/systems are meaningful for cultures other than the dominant cultures. The research on the usability of the PCS dictionary and graphic symbols for Indian children and youngsters revealed that there were cultural and social discrepancies in parts of speech for Indian learners, and such discrepancies were predominant in such categories as food, clothes, household furniture, social greetings, and festival/feast days. Research on PCS symbols representing words confirmed the existence of such social and cultural incompatibility.

On the other hand, Walker (1987), the designer of Makaton which is defined as a communication system that uses speech, sign, and symbols to develop the communication skills of individuals with language and learning difficulties, stated in one of his studies on the use and efficacy of Makaton in different languages and countries: “Changes reflecting the differences in the roles of family members, dietary habits, climate, setting and religious beliefs are necessary for the cross-cultural acceptability of the system.”

These graphics used worldwide are the systems developed for the English language grammar structure and studies on the adaptation and usability of these systems brought no significant results when considering the agglutinative structure of the Turkish Language. It proved that there is no graphic symbol system that has been developed for the agglutinating structure of the Turkish language and harmonized with the Turkish social, cultural and understanding system in terms of scope and content. This study took this as a starting point and aimed to design an alternative communication system for Turkish based on graphic symbols.

The studies on disabled population needing special education are rare in Turkey (Eres, 2010; Karal, 2014). Review of literature revealed that graphic symbol-based learning environments addressing needs of learners with varying level of disability are widespread in international arena. On the contrary, studies on individuals needing special education in Turkey are even more sparse. There is an obvious need for developing learning environments to meet needs of the individuals needing special education and alleviate disadvantageous situations by providing equality of opportunity in education. Proposed system contains the process of developing a content which would pave the way for Turkish in this context. Contemplated as an alternative means of communication for Turkish, the system is expected to give rise
for conventional and technology-aided learning environments which help individuals that are in need of special education develop their communication, reading and writing, vocabulary and concept learning with graphic symbols.

**Aim of the study**

This study was carried out to examine the process of designing a graphic symbol system as an alternative communication tool for individuals with communication deficiency. Its main purpose was to end up with a graphic symbol system that is in conformity with the structure of Turkish language and Turkish social, cultural and mental system. The study seeks answers to the following research questions:

- What is the designing process of a system containing suitable graphic symbols for Turkish like?
- How does the scope and content of developed system differ from the graphic symbol systems widely used in the literature?

**Method**

Mixed research methodology was used in this study. Mixed methodology broadens the diversity of methods and techniques available to researchers and permits to seek answers for research questions (Sale, Lohfeld, & Brazil, 2002; Johnson, & Onwuegbuzie, 2004; Creswell & Plano-Clark, 2007; Bryman, 2006; Fraenkel, Wallen & Hyun, 2008; Teddlie, & Tashakkori, 2011; Baki, & Gökçek, 2012). Given these advantages, mixed methodology was considered suitable for the present study. The study was carried out in order to develop a graphic symbol system for the Turkish language. This process requires collecting and analyzing data by using qualitative and quantitative instruments. As participants were asked for both written and verbal comments during the process of developing the visual graphic symbols. Also, questionnaires were used in order to find out the best examples of the visual graphic symbols developed.

**Study group**

The study was implemented as project number 110K257 supported by TÜBİTAK and ran for 30 months from 2010 to 2013. All activities were undertaken by a project team comprised of faculty members from the departments of Classroom Teaching, Turkish Language and Literature, Computer and Instructional Technologies Education, and Special Training for learning difficulties, and four scholarship students in Computer and Instructional Technologies Education at postgraduate level.

The common graphic symbol system was developed mainly in three stages. During these stages, groups of participants were formed with purposeful and convenient sampling. As it allows in-depth study of cases that are thought to contain a lot of information, purposeful sampling was used. At the same time, convenient sampling was used as it allows selecting samples from easily accessed and feasible units of the population considering the restrictions of time, cost and labor force in this study.

**Developing the graphic symbol system**

Graphic symbol studies emphasize the importance of the strong relation between a symbol and the object or concept it represents for its learnability and intelligibility (Fuller & Stratton, 1991; Cross, 1994; Schlosser, 1997). Most researchers checked this aspect of the graphics comprising the widely used graphic symbol systems in the literature in cooperation with different participant groups, and stressed the importance of graphic symbols being transparent, semi-transparent, and/or understandable or learnable (Mizuko, 1987; Glennen, & DeCoste, 1997; Hetzroni, Quist, & Lloyd, 2002; Brown, 2006; Cho, Ishida, Yamashita, Inaba, Mori, & Koda, 2007; Angermeier, Schlosser, Luiselli, Harrington & Carter, 2008).

In our study, three stages were proposed for developing the system: (i) determining the words to be included in the content of the system, (ii) drawing/describing visual representations of the words, and (iii) submitting such visuals to a large sample group/standardization. During the first stage, the words to be given in the system were selected. At
first, glossary lists of similar systems in the literature were reviewed to form a glossary. Then, it was asked “Would people with different social and cultural backgrounds from different parts of Turkey offer any other words for the glossary?” Departing from that, a group of participants was formed from teachers who had lived in different parts of Turkey in order to reflect the cultural diversity to the glossary within the framework of purposeful sampling. For convenience of access and application, the teachers were selected from the provinces where the teachers involved in developing the system were employed.

In the second and third stages, the visuals representing the selected words were drawn/described, and those visuals were submitted for opinion of a large sample group/standardization works, respectively. The system was proposed as an attempt to support communication, reading and writing, vocabulary and concept learning skills of individuals with varying disabilities. To this end, opinions of teachers for hearing-impaired and mentally-retarded were sought first. Besides, teachers from fields such as pre-school teaching, classroom teaching, visual arts or art teaching were included expecting that their respective fields were in compliance with uses of graphic symbols in the literature. Hence, as a part of the second and third stages of the system development process, participant groups were formed with purposeful sampling especially comprised of teachers for the hearing-impaired and mentally-retarded, pre-school, classroom, visual arts or art. In addition to the selected participants, other participants were included in the study on voluntary basis to share the work load during the second and third stages due to the time, cost and labor force restrictions. Those participants were selected taking into consideration the fact that convenient sampling allows selecting individuals from easily accessed and feasible units. On the basis of the maximum variety principle, it was aimed at obtaining and blending views of various groups. The stages in developing the system are displayed in Figure 1.

![Figure 1. The process of developing the system](image)

During development of the system, the number and description of all participants were provided in Table 1 as well as under the relevant headings in parallel with their involvement in the study.

<table>
<thead>
<tr>
<th>Stage</th>
<th>No. of participants</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Determining the lexical content of the system</td>
<td>25</td>
</tr>
<tr>
<td>2</td>
<td>Drawing/describing the visuals</td>
<td>106</td>
</tr>
<tr>
<td>3</td>
<td>Applying to a large sample group for their views on the visuals/standardization works</td>
<td>1,099</td>
</tr>
</tbody>
</table>
Stage 1: Determining the Lexical Content: The objective of this Stage was to obtain the views of participants from different cultural and social backgrounds regarding the content of the system.

Stage 2: Drawing/Describing the Visuals: Following Stage 1, visual representations of the selected words were described in this stage. The data collection instrument developed in this study were distributed to 400 participants with priority of teachers of the hearing-impaired, mentally retarded, pre-school, classroom, visual arts or art and some volunteer teachers. Feedback was obtained from 106 participants in total. This stage was completed in the province where the study is implemented on the basis of easy access. 38 of the participants returned the data collection documents without filling in the demographic info.

Stage 3: Applying to a large sample group for their views on the visuals/standardization works: During this stage, an online questionnaire was implemented in order to check consistency of the visuals yielded from Stage 1 and Stage 2 with a larger sample from all over Turkey. Online implementation of the two-stage questionnaire allowed involving views of participants from all over Turkey. In part one, 150 teachers and 439 students participated. The second part of this stage was carried out with 22 teachers and 405 students.

Data collection instruments/techniques

Visual design form

A new form was developed to determine the specifications of visuals to compose the graphic symbol system to be designed for Turkish. It was called the visual design form. The form was used as the main instrument for determining the content of the system.

The lexical content of other systems in the literature, the Turkish Sign Language Dictionary, and the list of concepts applicable for children of 32-76 months old in the preschool curriculum were examined, and a new dictionary was prepared. Twenty-five teachers from different cultural and social history at various schools were approached for their comments in order to identify entries to add to or omit from the dictionary.

Nearly 750 words were identified under 22 headings such as actions, persons, adjectives, social interaction. For determining visual figurations of these words, the form, which is a booklet, includes explanatory information regarding objectives and expectations, examples of graphic symbol affixes/words/sentences and a drawing area for each word. Moreover, the form allows participants to add words under relevant headings and draw/describe the corresponding symbol. An example from this data collection instrument is presented in Figure 2.

Figure 2. A page illustrating the space for graphic symbol explanations of words and adding new words

The purpose of using the design form was to determine the visuals representing the words provided, to determine general specifications for them and find out whether participants refer to common symbol(s) for each word or not.

Graphic symbol selection questionnaire (e-Measure)

In the graphic symbol selection questionnaire, each item represented one word and the graphic symbol(s) considered to represent that word were presented in a way that allows users to make a selection. For each word, from one to five graphic symbols were provided so that users could choose the best option(s). Prepared in multiple choice form, the questionnaire allowed participants to click to choose one of the symbols for each word. In cases where the graphic(s) given for each word were not sufficient and another graphic symbol was needed, the text space below the words was left for users’ to express their opinions. As a result, the authentic views of users could be included in the system.
The purpose of the online graphic symbol questionnaire was to obtain the views of a large group of participants selected from the Turkish population and to standardize the graphics of the system. A screen shot of the e-measure was displayed in Figure 3.

![Screen shot of e-measure: text space for alternative graphic symbols describing words such as wash, face, soft, and swim, and comment area for the word miserable](image)

**Figure 3.** Screen shot of e-measure: text space for alternative graphic symbols describing words such as wash, face, soft, and swim, and comment area for the word miserable

### Data collection process

Data collection using the data collection instruments began with the participants drawing/describing visuals using the visual design form. Then, the graphic symbol selection questionnaire derived from the collected data was presented to opinion of participants from all parts of Turkey for their comments on web. In this way, the graphic symbols were standardized. The stages in the development of the system to create standard graphics as well as the participants involved in these stages were given in Table 2, respectively.

<table>
<thead>
<tr>
<th>Table 2. Stages in developing the system</th>
</tr>
</thead>
<tbody>
<tr>
<td>Literature review</td>
</tr>
<tr>
<td>Determining the words/concepts to be included in the dictionary</td>
</tr>
<tr>
<td>Preparing the visual symbol system design form for Turkish</td>
</tr>
<tr>
<td>Describing/drawing visuals by participants using the visual design form</td>
</tr>
<tr>
<td>Analyzing and interpreting the data collected</td>
</tr>
<tr>
<td>Determining the visuals</td>
</tr>
<tr>
<td>Transferring the visuals into electronic media</td>
</tr>
<tr>
<td>Developing the graphic symbol selection questionnaire</td>
</tr>
<tr>
<td>Obtaining opinions of a large group of participants/standardization works by means of the graphic symbol selection questionnaire</td>
</tr>
<tr>
<td>Analyzing and interpreting the data collected</td>
</tr>
</tbody>
</table>

### Analysis of data collected with visual design study

The feedback received from participants via the visual design form (symbolic drawings for words) was transferred to electronic media and visuals corresponding to each word/phenomenon were filed in visual folder drawn/described using specialized software. The purpose of the filing was to determine the rate of visualization/descriptiveness of each word. Nearly 92,000 clip image files were examined; the graphics not containing any expression were omitted, and remaining common ideas were put into descriptive codes by three PhD students from the project implementation team who are experienced in graphic symbols. Due diligence was shown in order to avoid any inconsistency between analyses realized separately by researchers, and to this end the three researchers worked collaboratively before the study.
The folder containing visuals representing each word as well as general properties and common aspects they indicate were assigned to the graphic designers on the project team so that they could make the drawings accordingly. At this point, it was stressed that drawings which look like the objects or concepts they indicate by virtue of a line or brush stroke are important for the system (Hetzroni et al., 2002). Drawings by the graphic designers were examined, their consistency with the system was criticized, and corrections were made as necessary during weekly meetings. Finally, the visuals to form the content of the system were derived from the design forms and they were designed as graphic symbols for about 750 words under different titles in electronic media.

Analysis of data collected with graphic symbol selection questionnaire

A large sample group was approached for their opinion on the graphic symbols designed for 750 words in electronic media by using the e-measure, thereby completing the standardization stage. The objective was to determine as standard graphic symbols those visuals predominantly indicated by users for each word. For this, frequency (hit rates) of alternative graphics for each word was determined. In addition, participants’ comments about words and the best probable standard visual for each word were examined. Such examination and data analysis were carried out by three PhD students from the project implementation team who are experienced in graphic symbols. Often participants from different provinces of Turkey recommended editing an existing symbol or redesigning a symbol on the scale. Apart from these, other comments which were not useful or relevant to the outcome were received. The researchers grouped all these comments and recommendations in tables under headings such as word and number of recommendations, and the recommendation/number of participants recommending. Comments and recommendations covering no meaningful data in the scope of the study were excluded and grouped as “other.”

Findings

Findings from the visual design form

The data collected from participants regarding the graphic symbol system through employing the visual design form were examined. It was seen that the participants tried to express words included in the form by drawing or describing symbols or copying and pasting ready images. They could express concrete concepts or objects comfortably and define suitable symbols for such words. However, they left more blank spaces as they were required to symbolize abstract concepts. It was found that they could not provide representations especially for words regarding time/status, pronouns, affixes, adjectives, and persons, and most of the participants left such spaces blank. The participants indicated that the design form could be used for its determined purpose.

The drafts provided by 106 people were analyzed and it was found that a maximum of 77 graphics were proposed for words in the design while the minimum was 8 graphics. The highest number of drafts were provided for the term “reading,” while the least drafts were given for the Turkish affix “-dir.” Descriptive codings were displayed in the form of total number of ideas drawn/described per word, different ideas indicating the same word and the number of such ideas. An example of the statistical data obtained was demonstrated in Table 3. Recommendations considered irrelevant for the system were ignored and presented as “other” in the table.

<table>
<thead>
<tr>
<th>Word/ No. of ideas</th>
<th>Descriptions (Number of ideas)</th>
</tr>
</thead>
<tbody>
<tr>
<td>to read/ 77</td>
<td>A person reading a book (54), an eye reading a book (9), a book (12), other (2)</td>
</tr>
<tr>
<td>to find/ 55</td>
<td>A person with a shining light bulb above head (10), a light bulb (5), a person looking at something in excitement (15), money in the trash (1), a compass (2), many options with one of them filled in (1), other (21)</td>
</tr>
<tr>
<td>to make/43</td>
<td>A person drawing a picture (7), a person or hands doing or sorting something (20), a puzzle or hands doing a puzzle (2), a birthday cake (1), other (13)</td>
</tr>
<tr>
<td>mother/ 52</td>
<td>hair, a woman in skirt or scarf (28), a woman with a child (17), letter A (3), family tree (2), other (2)</td>
</tr>
<tr>
<td>Hodja Nasreddin/ 47</td>
<td>On the donkey (28), in his traditional cap (14), other (5)</td>
</tr>
<tr>
<td>Keloğlan/ 54</td>
<td>With his pack on his back (21), a bald boy (32), a pack (1)</td>
</tr>
<tr>
<td>dir- dir/ 8</td>
<td>other (6), a sandglass (1), a 6-checked form (1)</td>
</tr>
</tbody>
</table>
This statistical information was shown in Table 4 along with example drawings and descriptions made by participants.

<table>
<thead>
<tr>
<th>Word</th>
<th>Drawings/Descriptions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>To read</strong></td>
<td></td>
</tr>
<tr>
<td>A person reading a</td>
<td><img src="image_url" alt="Image" /></td>
</tr>
<tr>
<td>book (54)</td>
<td><img src="image_url" alt="Image" /></td>
</tr>
<tr>
<td>An eye reading a book</td>
<td><img src="image_url" alt="Image" /></td>
</tr>
<tr>
<td>(9)</td>
<td><img src="image_url" alt="Image" /></td>
</tr>
<tr>
<td>A book (12)</td>
<td><img src="image_url" alt="Image" /></td>
</tr>
<tr>
<td>Other (2)</td>
<td><img src="image_url" alt="Image" /></td>
</tr>
<tr>
<td><strong>To find</strong></td>
<td></td>
</tr>
<tr>
<td>A person with a shining bulb above head (10)</td>
<td><img src="image_url" alt="Image" /></td>
</tr>
<tr>
<td>A light bulb (5)</td>
<td><img src="image_url" alt="Image" /></td>
</tr>
<tr>
<td>A person looking at something in excitement (15)</td>
<td><img src="image_url" alt="Image" /></td>
</tr>
<tr>
<td>Money in the trash (1)</td>
<td><img src="image_url" alt="Image" /></td>
</tr>
<tr>
<td><strong>To make</strong></td>
<td></td>
</tr>
<tr>
<td>A person drawing a picture (7)</td>
<td><img src="image_url" alt="Image" /></td>
</tr>
<tr>
<td>A person or hands doing or sorting something (20)</td>
<td><img src="image_url" alt="Image" /></td>
</tr>
<tr>
<td>A puzzle or hands doing a puzzle (2)</td>
<td><img src="image_url" alt="Image" /></td>
</tr>
<tr>
<td>Birthday cake(1)</td>
<td><img src="image_url" alt="Image" /></td>
</tr>
<tr>
<td><strong>Mother</strong></td>
<td></td>
</tr>
<tr>
<td>Hair or a woman in skirt or scarf(28)</td>
<td><img src="image_url" alt="Image" /></td>
</tr>
<tr>
<td>A woman with a child (17)</td>
<td><img src="image_url" alt="Image" /></td>
</tr>
<tr>
<td>Letter A (3)</td>
<td><img src="image_url" alt="Image" /></td>
</tr>
<tr>
<td>Family tree (2)</td>
<td><img src="image_url" alt="Image" /></td>
</tr>
</tbody>
</table>
In the light of the ideas drawn from the data obtained through the design form, the process of graphic design in electronic media was launched. More than one idea was proposed for most of the words, which required more than one drawing. In cases where alternative graphics were needed for words besides data obtained through the design form, the literature review was referred to. Visual dictionaries and pictures, illustrations, vector databases of the popular symbol systems were examined in the literature. As a result, one to five graphic symbols were designed to represent each word.

The system was configured in such a way as to describe the settings in which a character called Aliş is by himself, with his friends or adults in daily life. Actions, adjectives, pronouns, and professions were designed in relation to the character Aliş. Sample drawings indicating terms such as “to read,” “to find,” “to make,” “mother,” “to look,” “Hodja Nasreddin,” “to think,” “to count” and affixes such as “-ing,” “-dır” (am-is-are), respectively, are given in Table 5.

Table 5. Sample drawings

<table>
<thead>
<tr>
<th>Term</th>
<th>Illustration</th>
</tr>
</thead>
<tbody>
<tr>
<td>To read</td>
<td><img src="image-url" alt="Illustration" /></td>
</tr>
<tr>
<td>To find</td>
<td><img src="image-url" alt="Illustration" /></td>
</tr>
<tr>
<td>To make</td>
<td><img src="image-url" alt="Illustration" /></td>
</tr>
<tr>
<td>Mother</td>
<td><img src="image-url" alt="Illustration" /></td>
</tr>
<tr>
<td>To look</td>
<td><img src="image-url" alt="Illustration" /></td>
</tr>
<tr>
<td>Hodja Nasreddin</td>
<td><img src="image-url" alt="Illustration" /></td>
</tr>
<tr>
<td>To think</td>
<td><img src="image-url" alt="Illustration" /></td>
</tr>
<tr>
<td>To count</td>
<td><img src="image-url" alt="Illustration" /></td>
</tr>
<tr>
<td>-ing</td>
<td><img src="image-url" alt="Illustration" /></td>
</tr>
<tr>
<td>-am-is-are</td>
<td><img src="image-url" alt="Illustration" /></td>
</tr>
</tbody>
</table>

Findings from the graphic symbol selection questionnaire

Graphic symbols for words drawn in electronic media were shared with participants for their opinions by using the graphic symbol selection e-measure. Data were collected in two stages through the questionnaire sent via electronic means. In the first stage, the maximum and minimum numbers of participants such as teachers, students and others expressing their views about items in the questionnaire were 654 and 216, respectively.

The purpose of this activity was to appoint as standard symbols the graphic symbols predominantly indicated by participants for each word. In this context, 2,772 comments and recommendations made by participants regarding words and the best probable standard graphic symbols for these words were uploaded to the system. Obtained data were analyzed. An example of analyzed data was shown in Table 6.

Table 6. Participants’ comments/recommendations regarding graphic symbols shared through e-measure

| Word     | No. of recommendation | Recommendation/No. of persons recommending                                                                 |
|----------|-----------------------|----------------------------------------------------------------------------------------------------------|---|
| To read  | 17                    | The confusion and boredom on the face should be removed (4)                                               |    |
|          |                       | Mouth shape as in reading aloud (1)                                                                       |    |
|          |                       | Book could be on the desk (1)                                                                           |    |
|          |                       | Real pictures could be used (1)                                                                          |    |
|          |                       | Other                                                                                                     |    |
| To find  | 33                    | The face in picture three should look happy (2)                                                           |    |
|          |                       | To discover something you look for under a sheet or object (6)                                             |    |
|          |                       | A concrete object should be discovered (4)                                                                |    |
|          |                       | In picture one, what is looked for should be around the character (2)                                      |    |
|          |                       | There should be a question on the board in picture one (1)                                                |    |
|          |                       | Other                                                                                                     |    |
Some part of the object could be seen in picture one (7)
Objects look suspended in picture one (2)
Other

“i” or “ve” (and) should exist (2)
Neither is compliant with our culture (1)
Other

To show something ahead of the objects in front (2)
This picture gives the meaning of “different” (5)
There should be figures in a cluster with one separated (1)
Other

The graphic symbols were revised or redesigned according to the feedback received from participants using the graphic symbol selection e-measure. The e-measure was updated with new graphic symbols designed at the end of the process. Besides, new entries were gradually added to the dictionary (total number of entries increasing to 843 finally), and graphic symbol illustrations derived from the literature review were added. Then, the second stage of the standardization followed.

The revised e-measure was sent to 445 participants for their opinions in addition to the standardization works in stage 1. Respondents provided 1,576 comments and recommendations on the graphic symbols. Examination of the responses showed that most of the comments made by participants did not include any clues for improvement of the graphics making up the system. At this point of the study, the total number of participants involved in the questionnaire was given in two groups as stage 1 and 2 in Table 7.

<table>
<thead>
<tr>
<th>No. of participants</th>
<th>No. of recommendations/ comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stage 1</td>
<td>654</td>
</tr>
<tr>
<td>Stage 2</td>
<td>445</td>
</tr>
<tr>
<td>Total</td>
<td>1,099</td>
</tr>
</tbody>
</table>

Standard graphic symbols defining words presented in the e-measure were shaped in the light of comments made by participants from all over Turkey with different social and cultural backgrounds. The graphic symbol(s) predominantly indicated by participants for each word was/were appointed as graphic symbol(s) representing that word. While for some words only one graphic symbol was frequently chosen by participants, more than one graphic symbol was chosen for indicating the same word for some other words. Examples of alternative graphic symbols shared with participants through the e-measure and hit rates by participants were presented in Table 8.

<table>
<thead>
<tr>
<th>Word/ Hitting rate</th>
<th>Alternative symbols</th>
</tr>
</thead>
<tbody>
<tr>
<td>Read/ 863</td>
<td><img src="image" alt="Read Symbol" /> <img src="image" alt="Book Symbol" /></td>
</tr>
<tr>
<td></td>
<td>142</td>
</tr>
<tr>
<td>Find/ 845</td>
<td><img src="image" alt="Thought Symbol" /> <img src="image" alt="Search Symbol" /> <img src="image" alt="Spring Symbol" /> <img src="image" alt="Clown Symbol" /></td>
</tr>
<tr>
<td></td>
<td>510</td>
</tr>
</tbody>
</table>
As a result of the analysis of the data collected through the e-measure, standard graphic symbols were identified for 843 words. The opinions of 1,099 participants on the graphic symbols were received. Different numbers of opinions, namely hit rates, were noted for each word. The minimum hit rate was found to be around 226, whereas it was above 800 for most words. A graphic dictionary was created on the basis of these hit rates. The graphic symbol dictionary can be seen at www.alis.org.tr.

In summary, all findings from analysis of the data collection instruments put forward a graphic symbol system that can be used as an alternative communication means for Turkey. The system comprised of 843 words and 7 types of affixes, and allows writing sentences with graphic symbols in conformity with agglutinative structure of the Turkish language. A sample sentence produced by the system was given in Figure 4.

**Discussion**

In development stage of the widely used graphic symbol systems such as Blissymbols, Makaton, PCS, Picssyms and Widgit Literacy Symbols, the overall process was started by one or several researchers. For instance, the Blissymbolic was introduced as a result of an attempt to create an easy-to-use international language inspired from the Chinese writing system. Researcher Bliss developed the new non-alphabetical writing system called “Blissymbolics” based on 100 basic forms (Carmeli, & Shen, 1998). Rebus, which constitutes the basis of the Widgit symbols, were first used as a part of a reading program in the United States. Later, it updated by two researchers to help linguistic development of students with learning difficulty resulting in use of the rebus in another school in England (Whittle, & Detheridge, 2001; Dixon, 2001). Makaton was devised by a speech therapist and two supervisors from a Psychiatric Hospital supporting the deaf-mute and the system was ultimately named “Makaton” associated with first names of the researchers (Walker, & Armfield, 1981). On the contrary, such systems are today developed by a team consisting of speech therapists, educators, psychologists, designers, students with special training need and even parents. In our study, the system developing process was implemented by following the stages in an opposite order. In order to develop understandable graphic symbols that have strong relations with referred objects or concepts (Glennen, & DeCoste, 1997), opinions of groups from all provinces of Turkey were taken as a basis. The purpose was to provide transparent, semi-transparent or understandable graphic symbols (referred as iconicity in the literature).
Graphic symbol systems are used in many countries. Though configured in accordance with grammar of English as a lexis-based language, such systems are also available adopted in other languages. However, there was not found a version which could enable making up sentences in Turkish as an agglutinative language. Graphic glossaries of current systems were translated into Turkish language only by keeping the graphic dictionary unchanged. Still, no individual system is eligible for writing graphic sentences in Turkish taking into consideration its affix structure. The system developed in our study was configured in a way to allow making up sentences with graphic symbols introduced for a total of 843 words and 7 types of affix. It constitutes the first example answering the question “It is possible to write in Turkish with graphic symbols?”

Development of our system was started with determining the words to be covered by the system scope. For this, glossaries of the most common systems in the literature were examined. Especially, the core glossary of 450 concepts of the Makaton system obtained from the long-lasting and in-depth works with the deaf and mentally retarded subjects (Walker & Armfield, 1978) was scrutinized. As a result, many words were excluded from the glossary due to the discrepancy with English and Turkish language structures. On the other hand, some other words were determined for adding. In this scope; Makaton glossary provides “children, boy, girl, less/ more, how old, last week/month/year, next week/month/year, my, your, her/his/its, mine, yours, hers/his/its, you/you, etc.” as separate entries. Owing to the fact that new words can be derived from roots by using affixes in Turkish, most words were omitted or revised. Furthermore, new terms were added related to family relations, money, historical or mystical characters and festivals. For example, “aunt (father’s sister), uncle (mother’s sister), sister-in-law (brother’s wife), 10 tl, 20 tl, 100 tl, Atatürk, Fatih Sultan Mehmet, Mevlana, Nasrettin Hoca, Keloğlan, Cumhuriyet and so on” were included in the glossary.

Conclusion and recommendations

It is highlighted in the literature that visual materials are particularly useful in cases where individuals are experiencing difficulties in comprehension and need special training; pictures and drawings are often used to this end. Our study was proposed as an outcome of the attempts to create content particularly for Turkish. For those suffering from speech and learning difficulty and thus in need of special education, the language was restructured in a way to allow forming comprehended Turkish content with graphic symbols.

It is noted that most technological products based on graphic symbols are equipped with auxiliary technologies in order to offer flexible access opportunities for individuals needing special training. As an example, mobile devices are equipped with features which can be adapted to learning disabilities and help regulate productivity and academic performance for reading ability, mathematics, writing, and so on. Research investigating the extent to which graphic symbols are integrated with technology, from lower technology devices to games, revealed that products supporting the educational needs of students and changing/developing curricula are extensive. In this scope, it is recommended to make the best use of technology in order to ensure equality of opportunities between those in need of special training and the general population. Lastly, learning media/materials based on the graphical symbol system developed in this work can be developed to meet the individual needs of disabled students and eliminate their disadvantages in learning.

References


Students with Special Health Care Needs in K-12 Virtual Schools

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*Corresponding author

ABSTRACT

This study sought to establish a baseline for understanding the epidemiology of online K-12 students with special health care needs, determine the prevalence in K-12 online schooling of students from certain racial/ethnic backgrounds, those with socioeconomic disadvantages, and determine how these students perform in online classes compared to their prior experiences in traditional, face-to-face programs. Data from two different studies was used to address these questions with the goal to support virtual K-12 schools, blended programs, and teachers as they continue to implement best practices for all students. Students with special health care needs attending virtual school are underrepresented in the literature. A possible explanation is that these students are not identified. However, current research suggests that high-risk students, with or without a disability, are choosing virtual school as a viable option (Cavanaugh, Repetto, & Wayer, 2011). The Children with Special Health Care Needs screener can be used to identify these students in order to provide support beyond their Individualized Education Program (IEP). Students who need extra support, self-pacing, or cannot attend school physically can potentially benefit from virtual schooling.

Keywords

Virtual schools, Students with special health care needs, K-12 learning, Online education, Child with special health care needs screener

Introduction

K-12 online education is growing exponentially. A 2007 national study found that 700,000 American K-12 students were enrolled in at least one online or blended course; the number rising to 1,030,000 in a 2009 follow-up study (Picciano, Seaman, Shea, & Swan, 2011). The most recent version of the Keeping Pace Report highlights online learning opportunities in all 50 states and the District of Columbia (Watson, Murin, Vashaw, Gemin, & Rapp, 2011). As new programs are created and existing ones are evaluated, there is a need for research that can assess various components of online education. Studying how students and instructors adapt in a virtual learning environment is one of those important research topics (Oliver, Osborne, & Brady, 2009).

Although many colleges of education are still lagging behind teacher preparation in virtual schooling environments, research in online K-12 instruction has emerged (Ferdig, Cavanaugh, & Freidhoff, 2012). For instance, DiPietro, Ferdig, Black, and Preston (2008) found online instructors need to learn skill sets similar to those practiced in face-to-face K-12 instruction, similar to those practiced in online post-secondary instruction, and unique to the K-12 online environment. Oliver et al. (2009) summarized three categories of instructor online competency which consist of managing the online learning environment, preparing content, and utilizing tools for desired outcomes. Rice, Dawley, Gasell, and Flores (2008) provided evidence that online teachers have little to no experience working with students with disabilities, especially in distance education. More research in online instruction will be required as the technologies change and enrollments increase.

Some research has also been completed in the area of understanding the K-12 online student. For instance, Forrester and Parkinson (2006) noted that student expectations may stem from prior experience, communication with peers who have taken an online course, or their own learning assessments. Lao and Gonzales (2005) argued for understanding students’ attitudes, perceptions, and experiences about online education in order to deliver quality virtual education. Finally, Roblyer and Marshall (2002) identified several psychological factors necessary for academic success in K-12 online environments; these factors include technological skills, self-discipline, time-management skills, internal locus of control, self-esteem, responsibility, and achievement motivation.
Less is known about how K-12 online schooling provides educational opportunities for populations known to have health and educational challenges, such as those from certain racial/ethnic backgrounds, those with socioeconomic disadvantages, and children with special health care needs (Thompson, Ferdig, & Black, 2012; Cavanaugh, Gillan, Kromrey, Hess, & Blomeyer, 2004; Dickson, 2005; Repetto, Cavanaugh, Wayer, & Liu, 2010; Müller, 2009). This is a critical area of research and its implications on practice as the advantages of virtual schooling for such students are substantial. Students who need extra support, self-pacing, or cannot attend a school physically (e.g., are homebound or hospitalized) could all potentially benefit from this medium of instruction.

The broad goals of this article are three-fold: Establish a baseline understanding of the epidemiology of online K-12 students, to determine the prevalence in K-12 online schooling of children from certain racial/ethnic backgrounds, those with socioeconomic disadvantages, and children with special health care needs, and to determine how these children perform in online classes compared to their prior experiences in traditional, face-to-face programs. In order to address these questions, this article reports data from two different studies. The first study contains epidemiological data acquired from students across three states; the second study is a deeper exploration through a follow-up study from a leading virtual school in one of those states. The article ends with conclusions and implications for research and practice. The goal of this work is to support virtual K-12 schools, blended programs, and teachers as they investigate best practices in working with all students.

**Research study #1**

The purpose of the first study was to determine and describe the demographics of students attending three state-led Virtual Schools (VS) by quantifying results from a parental survey distributed to those schools. State-led virtual schools are associated with state Departments of Education, which provides some similarity in the scope and nature of their operations. The three schools represented in this first study were those that had originally participated in data collection and analyses of existing practice through the Virtual School Clearinghouse (http://www.vsclearinghouse.com). The Virtual School Clearinghouse was a project funded by AT&T to help virtual schools improve their teaching and learning practices, mainly through the use of data-driven decision-making.

**Method**

The research team began by creating and pilot-testing a parent survey that would take about five minutes to complete. The parent survey was constructed to assess four domains: (1) Basic demographic and educational history of the child; (2) parental education; (3) the Child with Special Health Care Needs Screener (CSHCN); and (4) the child’s experiences with online classes. The CSHCN (Bethell, Read, Stein, Blumberg, Wells, & Newacheck, 2002) was chosen to bridge medical and educational outcomes. Traditional education screeners often cite learning disabilities, emotional disturbances, or speech and language impairments (Müller, 2009). The CSHCN, however, uses a comprehensive approach to health; it is a well-validated screener with five constructs aimed at identifying children with chronic or special health care needs (The Child and Adolescent Health Measurement Initiative, n.d.; Bethell, Read, Blumberg, & Newacheck, 2008). The CSHCN then sums the health consequences into three non-exclusive domains of: (a) dependency on prescription medications; (b) service use above that considered usual or routine; and (c) functional limitations. Approximately 15% of the general public and 20.7% of those enrolled in Medicaid screen positive with this screening tool (Carle, Blumberg, & Poblenz, 2011).

Parents of students attending of the three participating virtual schools were sent emails requesting participating in the survey. Email addresses were provided by the three participating schools; parents were only emailed once and were provided with the opportunity to “opt-out” of the survey through a link within the email. Data were collected electronically and then all univariate, bivariate, and multivariate analyses were conducted with STATA version 9.2 (College Station, Texas). The accepted level of significance was $p < .05$. 


Results

The response rate for the survey was 14.7% (N = 1,971), with states individually ranging from 10.1% to 20.3%. Such a rate is acceptable and consistent with other email-based parental surveys where there is a lack of incentive for participation (Manfreda, Bosnjak, Berzelak, Hass, Vehovar, & Berzelak, 2008). Reasons for not completing the survey were varied. Approximately 6% of emails were no longer valid, some parents chose to opt out, and some parent responses were removed because of incomplete information.

Demographics

A majority of respondents had children who were 15 to 18 years-old (86.9%). A second important finding was that 24.6% of the respondents were from parents of students with special needs or health care needs, which is significantly greater than the general population (~15%; Carle et al., 2011). Overall, parents participating in this survey were more likely to have obtained a bachelor’s degree compared to parents with children attending traditional schools. Respondents were more likely to report having a female child (57.9%) or a child who was white (70.9%). While there was some variation by state, overall there were fewer African-American and Hispanic students and more children of other or mixed races and ethnicities than in traditional schools.

Parent responses indicated that there was no difference in the distribution of student grades (A, B, C, D, or failing) in the online school as compared to their grades in a traditional school. A majority reported their child’s educational success as “very good” or “excellent” (62.9%); however, this varied between states (52.7%-70.0%). Several reasons for taking online courses were reported, although the majority of parents (76.0%) indicated that their child took a course because it was not offered at their school, they wanted to supplement their education, or they experienced scheduling difficulties. Some students (15.8%) took classes for credit recovery or as an alternative resulting from behavior concerns, while only a small number (8.2%) said their child took online classes to accommodate a health concern.

Educational success

It was possible to match the student’s traditional grade with their online grade in 61% of the cases. When comparing these grades, certain populations consistently reported low performance. In general, boys, African-American students, and children with special health care concerns had significantly lower grades. This was compared to female students, “white, Hispanic, and Others,” and healthy children (respectively), using non-overlapping confidence intervals of grades. Comparisons between traditional and online schools yielded no differences, even within subgroups. Online schools and traditional schools seem to have similar success rates within populations in straight, unadjusted comparisons.

However, advanced multivariate regression techniques that adjust for known educational performance factors further clarified these univariate trends. Controlling for age, gender, race, and parental education, children with special health care needs and African-American children were significantly more likely to have lower grades in online classes than their usual grades in traditional classrooms (aOR 1.45, 95% CI 1.29-1.62 for CSHCN, p < .001; aOR 2.73, 95% CI 2.11-3.53 for African-American children, p < .001.) Additionally, children whose parents have a bachelor’s degree or higher were more likely to perform better in online schools (aOR 1.45, 95% CI 1.15-1.82, p < .001).

Research study #2

The second study sought to explore the enrolling population of students using a large state-led virtual school. The idea in moving from three schools to one specific school was to be able to dig more deeply into the student grades and past experience. The goal was to obtain the demographics of students enrolled at the school, their educational success measured by course grade, the most recent course taken, the reason for taking a virtual course, and if a child has health conditions as indicated by the CSHCN validated screener.
Methodology

Parental or custodial email addresses were obtained from the state-led virtual school. Parents were then emailed the same survey instrument used in research study #1. Parents were only emailed once and were provided with the opportunity to “opt-out” of the survey through a link within the email. Data were collected electronically and then all univariate, bivariate and multivariate analyses were conducted with STATA version 9.2 (College Station, Texas). The accepted level of significance was $p < .05$.

Results

The survey reports descriptive data on 3,884 parents of the state-led virtual school students. Table 1 describes the demographics of the virtual school students. The gender distribution is equal with both males and females at 50%. The majority of the students fell within the 15-18 year old category. The sample consisted of 71.8% White students followed by 10.7% Hispanic, 7.5% African-American, and 9.5% Other/Mixed as reported by the parent. The virtual school sample represents a higher proportion of White students in comparison to the traditional school population. 24.3% of parents reported that their child has a special health care need. This figure is higher than traditional school where ~13.3% of students have a disability.

Table 1. Demographics of students enrolled in virtual and traditional schools (Thompson et al., 2010)

<table>
<thead>
<tr>
<th>Gender</th>
<th>Virtual school population (n = 3,884)</th>
<th>Traditional school population</th>
</tr>
</thead>
<tbody>
<tr>
<td>% Female</td>
<td>50.0%</td>
<td>--</td>
</tr>
<tr>
<td>% Male</td>
<td>50.0%</td>
<td>--</td>
</tr>
<tr>
<td>Age distribution</td>
<td></td>
<td></td>
</tr>
<tr>
<td>≤10 years</td>
<td>0.7%</td>
<td>--</td>
</tr>
<tr>
<td>11-14 years</td>
<td>34.4%</td>
<td>--</td>
</tr>
<tr>
<td>15-18 years</td>
<td>64.6%</td>
<td>--</td>
</tr>
<tr>
<td>19+ years</td>
<td>0.2%</td>
<td>--</td>
</tr>
<tr>
<td>Race/Ethnicity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>% White</td>
<td>71.8%**</td>
<td>45.9%**</td>
</tr>
<tr>
<td>% Hispanic</td>
<td>10.7%**</td>
<td>24.7%**</td>
</tr>
<tr>
<td>% African-American</td>
<td>7.5%**</td>
<td>23.1%**</td>
</tr>
<tr>
<td>% Other/mixed</td>
<td>9.5%**</td>
<td>6.3%**</td>
</tr>
<tr>
<td>Health</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Students with one or more special health care need(s)</td>
<td>24.3%</td>
<td>--</td>
</tr>
<tr>
<td>Students with disabilities</td>
<td></td>
<td>13.3%</td>
</tr>
<tr>
<td>Parental education</td>
<td></td>
<td></td>
</tr>
<tr>
<td>% without Bachelor’s degree</td>
<td>53.6**</td>
<td>72.8%**</td>
</tr>
<tr>
<td>% Bachelor’s degree or higher</td>
<td>46.4**</td>
<td>27.2%**</td>
</tr>
</tbody>
</table>


Table 2 reports the virtual school grade for 3,547 of the respondents. A majority of parents (1,369; 38.6%) reported a grade of “A,” 809 (22.8%) reported a grade of “B,” 174 (4.9%) reported a grade of “C,” 46 (1.3%) reported a grade of “D” or lower, and 1,011 (28.5%) of the grades were unknown. A virtual school course, still in progress at the time of data collection, accounted for the large percentage of unknown grades. When the virtual school grades were compared to the usual grades earned in traditional school, grades were similar in the A and B categories.

Comparing a student’s virtual school grade with their parent reported usual grade in traditional school was possible in 1,321 students or 34.5% of the respondents. In Table 3, the two types of grades were compared using student demographics, supporting the evaluation of outcomes in both traditional and virtual school. The grades were
averaged using a 4-point scale with A = 4.0, B = 3.0, C = 2.0, D = 1.0. Grades for both usual (traditional school) and virtual school were parent-reported. Overall, students performed better in virtual school courses across categories for gender, race, and the presence or absence of a special health need. Females performed slightly higher in both school formats in contrast to their male counterparts. African-American students performed lower than students of other races, but still earned higher grades in virtual school than in traditional school. Both students with and without a disability performed better in virtual school. However, students with a disability averaged almost half a grade higher in virtual school than in traditional school.

Table 2. Educational assessment by usual and virtual school grades

<table>
<thead>
<tr>
<th></th>
<th>&quot;Usual&quot; grades (Traditional schooling)</th>
<th>Virtual school grade</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n = 3663</td>
<td>n = 3547</td>
</tr>
<tr>
<td>% As</td>
<td>42.5</td>
<td>38.6</td>
</tr>
<tr>
<td>% Bs</td>
<td>30.8</td>
<td>22.8</td>
</tr>
<tr>
<td>% Cs</td>
<td>15.7</td>
<td>4.9</td>
</tr>
<tr>
<td>% Ds or less</td>
<td>5.8</td>
<td>1.3</td>
</tr>
<tr>
<td>Unknown</td>
<td>0.7</td>
<td>28.5</td>
</tr>
</tbody>
</table>

Table 3. Educational success by demographic category (n = 1,321) (Thompson et al., 2012)

<table>
<thead>
<tr>
<th>Race/Ethnicity</th>
<th>&quot;Usual&quot; grade (traditional schooling)</th>
<th>Virtual school grade</th>
</tr>
</thead>
<tbody>
<tr>
<td>% White</td>
<td>3.33 (3.30-3.38)**</td>
<td>3.52 (3.49-3.57)**</td>
</tr>
<tr>
<td>% African-American</td>
<td>2.98 (2.95-3.03)**</td>
<td>3.42 (3.38-3.46)**</td>
</tr>
<tr>
<td>% Hispanic</td>
<td>3.10 (3.01-3.11)**</td>
<td>3.45 (3.37-3.53)**</td>
</tr>
<tr>
<td>% Other/Mixed</td>
<td>3.21 (3.09-3.33)*</td>
<td>3.43 (3.30-3.56)*</td>
</tr>
<tr>
<td>Children with one or more special health care need(s)</td>
<td>2.92 (2.86-3.00)**</td>
<td>3.38 (3.32-3.44)**</td>
</tr>
<tr>
<td>Children with no special health care need</td>
<td>3.23 (3.2-3.26)**</td>
<td>3.50 (3.47-3.53)**</td>
</tr>
</tbody>
</table>

Note: *p < .05. **p < .01. A = 4.0; B = 3.0; C = 2.0; D = 1.0 (95% confidence intervals).

The most recent virtual course taken is represented in Table 4. Mathematics was the most common subject with 1,639 parents reporting that their child was taking a course in this area. Math was followed by Language Arts (1,246), Science (1,203), Social Studies (1,120), Foreign Language (758), other such as Technology or Business (316), and unknown (57).

Table 4. Recent virtual school course

<table>
<thead>
<tr>
<th>Subject area</th>
<th># of enrollments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mathematics</td>
<td>1,639</td>
</tr>
<tr>
<td>Language Arts</td>
<td>1,246</td>
</tr>
<tr>
<td>Science</td>
<td>1,203</td>
</tr>
<tr>
<td>Social Studies</td>
<td>1,120</td>
</tr>
<tr>
<td>Foreign Language</td>
<td>758</td>
</tr>
<tr>
<td>Other (e.g., Technology, Business)</td>
<td>316</td>
</tr>
<tr>
<td>Unknown</td>
<td>57</td>
</tr>
</tbody>
</table>

Table 5. Reasons for enrolling in a virtual school course

<table>
<thead>
<tr>
<th>Reason</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Homeschooled/Curriculum Augmentation</td>
<td>38.9%</td>
</tr>
<tr>
<td>Child needed to take again</td>
<td>31.9%</td>
</tr>
<tr>
<td>Unable to attend school because of health concerns</td>
<td>10.4%</td>
</tr>
<tr>
<td>School did not offer/scheduling difficulties or</td>
<td>11.9%</td>
</tr>
<tr>
<td>Unable to attend school because of disciplinary concerns</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>4.9%</td>
</tr>
</tbody>
</table>

71
Most of the parents reported that the virtual school course was used to augment the curriculum or for homeschooling their child (38.9%). Other results included 31.9% of the students were taking the course again, 10.4% of students were unable to attend school due to health concerns, 11.9% stated that the regular school did not offer the course, there were scheduling difficulties, or the child was unable to attend school for disciplinary reasons, and 4.9% selected “other” (see Table 5).

A total of 24.3% of parents reported that their child had a special health care need. Based upon these numbers, FLVS students had an average of 1.72 diagnoses (Thompson et al., 2010). Asthma and/or allergies were the most common medical diagnosis accounting for 47%. 38% of parents reported that their child had attention deficit disorder, with or without hyperactivity. The “other” category (24.8%) included 130 different diagnoses including cancer, acne, and pregnancy. Depression, anxiety, eating disorders, and other emotional problems (24.6%) were inclusive of nearly a quarter of the student health diagnoses (see Table 6).

<table>
<thead>
<tr>
<th>Diagnosis</th>
<th>Number</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asthma and/or Allergies</td>
<td>444</td>
<td>47.00%</td>
</tr>
<tr>
<td>ADD/ADHD</td>
<td>359</td>
<td>38.00%</td>
</tr>
<tr>
<td>Other*</td>
<td>234</td>
<td>24.80%</td>
</tr>
<tr>
<td>Depression, Anxiety, Eating Disorder or Other Emotional Problem(s)</td>
<td>232</td>
<td>24.60%</td>
</tr>
<tr>
<td>Migraines or Frequent Headaches</td>
<td>123</td>
<td>13.00%</td>
</tr>
<tr>
<td>Autism or Autism Spectrum Disorder</td>
<td>63</td>
<td>6.70%</td>
</tr>
<tr>
<td>Diabetes</td>
<td>32</td>
<td>3.40%</td>
</tr>
<tr>
<td>Arthritis or Other Joint Problems</td>
<td>30</td>
<td>3.20%</td>
</tr>
<tr>
<td>Epilepsy or Other Seizure Disorder</td>
<td>25</td>
<td>2.60%</td>
</tr>
<tr>
<td>Heart Problem(s)</td>
<td>24</td>
<td>2.50%</td>
</tr>
<tr>
<td>Mental Retardation or Developmental Delay</td>
<td>13</td>
<td>1.40%</td>
</tr>
<tr>
<td>Blood Problem(s) (Including Sickle Cell Disease)</td>
<td>9</td>
<td>1.00%</td>
</tr>
</tbody>
</table>

Note. “Other” category includes cancer, visual impairment, auditory impairment, scoliosis, ulcerative colitis, and dermatological issues.

Discussion and implications

In both studies, a high number of participants indicated that there child has one or more special health care needs compared to children less than 18 years old identified in a national sample using the CSHCN screener (Bethell et al., 2002) and 13.6% of K-12 students (Snyder et al., 2009). This finding indicates that a large number of students with health needs are opting to enroll in virtual school to meet their educational needs. Although the response rates were acceptable given traditional, non-incentive-based, web surveys, the percentage of students in virtual schooling with health or special needs could be much higher.

This matches published research, which, according to Cavanaugh, Repetto, and Wayer (2011), suggests high-risk students with or without the presence of a disability are choosing virtual schooling at an increasing rate. While virtual programs are serving these students, teachers have limited experience in working with students with disabilities in an online environment (Cavanaugh et al., 2011). This warrants further research in identifying these students enrolling in virtual programs in addition to training teachers to serve these students in online classrooms. The combination will aid in meeting the needs of students with special health care needs with the outcome of enabling them to complete their virtual course or program of study.

There were differences in outcomes between the two studies. In both studies, students enrolled in virtual courses showed no significant grade difference in comparison to their parent-reported traditional school grades. Parents reported similar grades in both modalities. However, there were differences between the two studies when examining gender, race, and students with or without health needs. In study #1, boys, African-American students, and students with health needs scored significantly lower in their virtual courses. Additionally, African-American children and students with special health care needs scored significantly lower in virtual school classes than their traditional classes.
In comparison, these differences did not appear in study #2. There was consistency across gender, race, and students with or without health needs. Across all groups, parents reported a slightly higher grade in virtual school courses. Students maintained similar grades in both types of schools. For example, a student who usually earns a “B” maintained a “B” in virtual school. The results demonstrate that students are able to maintain grade stability across both learning environments.

Math courses were cited as the most frequent course taken in the virtual school examined. Math courses are linear in nature as math skills build from one module to the next. Mastery of these skills would require regular and timely practice which would then need to be demonstrated on a semester exam. Students with special health care needs may experience intermittent absences due to illness or hospitalization thus making math a challenging subject to take online. In a study of North Carolina Virtual School students, they reported learning less online and also were less likely to recommend online courses to their peers (Oliver et al., 2010). More research is needed to triangulate the outcomes of students with health needs taking math courses.

Homeschooling and curriculum augmentation (38.9%) accounted for the top reason students took virtual courses. This result is not surprising given the high number of reported students with health needs. Students with moderate to severe health needs are likely to participate in a home school program and thus enroll in virtual courses. Taking a course again (31.9%) was the second reason for course enrollment. More information is needed to ascertain whether the student is taking the course over for grade forgiveness or as a result of health issues that limited their ability to complete the course the first time around. According to an FLVS Legislative Brief, 21% of students enrolled to raise a grade/learning recovery, 9% were homeschooled, and only 1% was hospital homebound (Florida Virtual School, 2014). Since students can be enrolled in several courses at once or over time, more information is needed to conclude the reason why a specific course was taken and if health issues impacted their enrollment in any way.

Asthma and/or allergies were identified in almost half of the sample of students with health needs. Since students averaged 1.72 diagnoses, it is likely that asthma and/or allergies are present with other diagnoses (Thompson et al., 2010). ADD/ADHD, other, and depression/anxiety/eating disorder/emotional problems, comprised the top diagnoses behind asthma and allergies. More research is needed as to the severity of these illnesses and the impact they have on a child’s ability to study. Given the flexible nature of virtual education, students with health conditions may find greater success in this learning modality. Tracking CSHCN students over time will provide a better glimpse of the impact virtual learning has at meeting their educational needs.

Finally, students with parents who bachelor’s degrees or higher performed significantly better in online courses. More work needs to be completed to further understand the role of the parent in supporting student work. However, early research indicates that parent-student interactions have predictive effect related to student achievement, but parents and students differ in their perceptions of each other’s involvement in the academic process. Further, demographic variables, such as gender and socioeconomic status, affect the level of parental involvement perceived by students (Black, 2009).

Limitations

This study has several limitations that are worthy of discussion. First, even though there was an acceptable response rate for this type of survey, a limitation of surveys is always the population who responded. Additional research in this area, as well as refined research techniques through partnership with virtual schools, could aid these issues. Second, a majority of parents who responded had students between the ages of 15-18. Results may vary as online schooling goes into younger grades and ages. Third, parental access to email or technology can limit the number of responses and may put lower socio-economic families at a disadvantage for survey response. Fourth, student grades, recent course, reason, and health diagnoses are parent-reported and subject to social bias and recall error. Finally, students who were not successful in their course and subsequently dropped or received a grade of “F” may not be represented in this study. Students with severe health issues may experience intermittent school attendance and thus completing a course successfully could prove to be a challenge. Thus, the actual percentage of students with health issues could be higher than what was reported. Moreover, students who are no longer enrolled in virtual courses, with or without health conditions, may not have access to the survey thereby limiting the data that was collected.
Conclusion

Virtual school students with special health care needs are underrepresented in the literature. A possible explanation is that these students are not identified, emphasizing the need for research in this area. The Children with Special Health Care Needs screener is a valid and reliable instrument for identifying these students (Bethell et al., 2002). K-12 virtual education serves to meet many of the IEP accommodations such as extra time on assignments and one-on-one time. However, students with chronic health conditions may need support outside of the curriculum. By identifying and studying this sub-group, we can take the first step to meet their needs and guide them to success in a virtual environment. This may include asking parents to not only obtain any student IEP’s, but also to consider filling out the CSHCN screener.

In conclusion, it is worth returning to a comparison of the two studies. In study #1, African-American children and students with special needs scored significantly lower in virtual classes than they did in traditional classes. In study #2, these differences did not exist. The differences between the two studies could be attributed to who responded, the courses that were taken, or the state and virtual school where parents were surveyed. Regardless, these contrasting findings are not, in fact, exceedingly troublesome. As a matter of fact, they represent what research in technology has been discovering for decades—there will always be studies that report both results—often ending in a conclusion of “no significant difference” (Salomon & Gardner, 1986).

We as authors are not attempting to suggest that all research everywhere will indicate that students of a certain race or those with special needs will always do better in face-to-face environments that they do online. Instead, we are providing evidence of two studies where, at least in one case, this was true. This might suggest that the school in the second study had a very specific approach to working with students of different cultural backgrounds or those students who needed extra support for health or other reasons. As such, we return to what Ferdig calls the right question—“Under what conditions do these results occur?” (Ferdig, 2011). Under what conditions did the second school provide support for certain subgroups? Under what conditions did the first set of schools fail to provide such support structures? Data provided in this report confirm what we have known about face-to-face education for years—students enter with specific needs, both health and otherwise. Ignoring those needs, or even failing to seek a deeper understanding of the context of those needs, is a path to failing our students.

References


The Impact of Simulated Interviews for Individuals with Intellectual Disability

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ABSTRACT

The purpose of this research study was to explore the efficacy of role-playing and coaching in mixed-reality environments for the acquisition and generalization of social skills leading to successful job interview performance. Using a multiple baseline across participants design, five young adults with intellectual disability practiced interviewing in a mixed-reality environment and were rated on the use of appropriate social skills and overt behaviors during the mock interviews. Generalization and maintenance were assessed by the participant’s ability to display appropriate social skills and overt behaviors in a face-to-face interview in a live environment. The intervention demonstrated to be effective in fostering the acquisition of job interview skills in the mixed reality setting as well as generalization in face-to-face interviews.

Keywords

Employment skills, Intellectual disability, Mixed-reality technology

Introduction

Preparing students and families to cope with the challenges of transitioning into society is a complex process for any student and can be especially difficult for students with disabilities. The difficulty of transition is further substantiated by poor employment outcomes for students with disabilities in the United States (U.S.). Youth with disabilities are less likely to work (57% vs. 66%) once they complete secondary schooling as compared to the general population (Newman, Wagner, Cameto, & Knokey, 2009). The U.S. Bureau of Labor Statistics (BLS) (2014) reports the highest percentages of unemployed persons come from two groups: high school dropouts and people with disabilities. In October, 2015, the unemployment rate for individuals with disabilities (10.5%) was double the unemployment rate for those without a disability (4.6%) (Bureau of Labor Statistics, 2015). Even when possessing a high school diploma, an individual with a disability is far less likely to have a job than someone without a disability. For example, only 58% of individuals with disabilities are employed full-time up to four years out of high school and the majority of those individuals report having to work 2-3 part-time jobs to meet full-time hours (Newman et al., 2009).

These data are alarming and have societal implications beyond the financial well-being of individuals with disabilities and their families. The effects of unemployment are much greater than lack of income and can have a significant negative effect on happiness and life-satisfaction (Kassenboehmer & Hasiksen-DeNew, 2009). Employment has a great impact on quality of life; however, to become successfully employed there are prerequisite skills needed by all employees. One such skill is the ability to secure employment through the job interview.

Social skills can have a profound impact on an individual’s interview performance. The ability to identify overt or subtle cues in specific environments or situations, such as the job interview, can be the difference between a job offer and a job rejection (Smith & Matson, 2010; Wehmeyer & Schwartz, 1998). However, students with ID often struggle with social skills and self-advocacy behaviors that are expected to be displayed in successful interviews (Crites & Dunn, 2004). For example, first impressions are considered to be important (Allen, 1994; Brown, 2000; Hawkins, 2004; Shipley & Wood, 1996). First impressions are often based on one’s ability to appear confident yet humble in initial conversation and behavior. However, these conversational and behavioral fluencies are often difficult for individuals with ID to attain in natural environments. Self-advocacy curriculums that include social skills content such as being assertive but not aggressive, communicating successfully in individual and group settings, negotiating, compromising, using persuasion, being a good listener, and navigating community services are important for young adults transitioning into the postsecondary environments (Wehmeyer & Schalock, 2001). These skills are also vital for a successful job interview. While the ability to self-advocate and “sell yourself” is vital in interview settings for any individual (Harrington, 1997; Hawkins, 2004; Kissane, 1997), training and preparation for those with ID may be especially important since the job interview highlights conversational and behavioral fluencies. Unfortunately, “the receipt of life skills instruction in school is not related to the receipt of life skills training/therapy after school by either individuals with mild ID or moderate/severe ID...educators who believe in the value of a life skills curriculum
will need to be creative in its implementation and look towards transition plan and activities to provide students with the needed training” (Bouck, 2010, p. 1100).

Gonca and Karaman (2011) also posit that educators should be creative in reconsidering the aim of education and removing all imaginable constraints. Removing all constraints includes considering how technology can be used to teach students valuable social skills. Virtual learning environments are one such technological innovation that holds promise. Virtual environments have provided opportunities for students with disabilities to actively participate in learning while controlling the learning process by manipulating the inputs and outputs the students receive (Smith et al., 2014; Brooks, Rose, Attree, & Elliot-Square, 2002; Cobb & Sharkey, 2007). Virtual environments have also allowed students to acquire specific metacognitive skills (Brooks et al., 2002; Cobb & Sharkey, 2007; Rose et al., 2000) across a variety of settings. Most recently, social cognition training in virtual environments has shown significant increases in real life social and occupational functioning for young adults with high-functioning autism (Kandalaft, Didehbani, Krawczyk, Allen, & Chapman, 2012, Vasquez et al., in press). Virtual environments created specifically for use in education have also been used to help prepare pre-service and existing educators by providing opportunities to practice new methods of instruction and classroom management before stepping foot into the classroom (Andreasen & Haciomeroglu, 2009; Dieker, Hynes, Hughes, & Smith, 2008).

TLE TeachLivE™ is a mixed-reality laboratory that combines a physical space with simulated people. The TLE TeachLive™ laboratory prepares individuals in simulated situations that combine virtual individuals with realistic scenarios. TLE TeachLivE™ has been instrumental in training pre-service and in-service teachers, developing transition skills for students with significant disabilities, providing immediate feedback through bug-in-ear technology to pre-service teachers, developing discreet trial skills in teachers, and preparing teachers in the use of STEM-related instructional strategies (TLE TeachLivE, 2014). The advantage of using the TLE TeachLivE™ lab for this study was that the virtual interviewer could be reset and used for repeat experiences, thus the individual had the ability to repeat interviews without sacrificing the valuable first impression. The ability to manipulate impressions is unlike a real employment interview that only affords the interviewee one opportunity to make a first impression on the interviewer. Further, by taking advantage of the ability to practice interview skills with the multiple interviewers/interactors available in TeachLivE™, participants can be exposed to a variety of situations and experiences with the intention of desensitizing them to new experiences and even new interviewers.

The purpose of this exploratory study was to investigate the efficiency of providing interview practice in a virtual learning environment along with live, face-to-face behavioral coaching based on interview performance in order to promote generalization of the skills and behaviors to the natural setting with young adults with ID. The intervention was delivered as a treatment package. Specifically we asked the following two questions: (1) To what extent will the combination of interview practice in the TLE TeachLivE™ lab and coaching increase job interview performance for 18-22 year old participants with intellectual disability as measured by an interview rubric?, and, (2) Will social skills presented during job interviews, as demonstrated following the combination of interview practice in the TLE TeachLivE™ lab and coaching, transfer to a live simulated job interview for young adults ages 18-22 with intellectual disability? While virtual learning environments have been associated with gains in academic skills for certain groups, the ability to increase social skills in an interview setting would be a novel and, potentially, powerful use of virtual environments.

**Method**

**Participants**

This study included five 18-22 year-old participants with an intellectual disability. An intellectual disability is defined as significant, sub-average general intellectual and adaptive functioning which manifests during the developmental period and significantly delays an individual’s acquisition of academic skills (Florida Department of Education, 2015). All five participants attended a large public school transition program and had IQ scores in the 55-65 range. Key characteristics of each participant are summarized in Table 1 and described below.
Table 1. Descriptive summary of participant characteristics

<table>
<thead>
<tr>
<th>Name</th>
<th>Age</th>
<th>Sex</th>
<th>Transition program year</th>
<th>Prior interview experience</th>
<th>Strengths</th>
<th>Weaknesses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jane</td>
<td>18</td>
<td>F</td>
<td>Second</td>
<td>No</td>
<td>Adaptable</td>
<td>Timid, Needed support</td>
</tr>
<tr>
<td>Anne</td>
<td>20</td>
<td>F</td>
<td>First</td>
<td>No</td>
<td>Motivated</td>
<td>Made progress</td>
</tr>
<tr>
<td>Carlitos</td>
<td>20</td>
<td>M</td>
<td>Second</td>
<td>Yes</td>
<td>Outgoing</td>
<td>Motivated</td>
</tr>
<tr>
<td>Elana</td>
<td>21</td>
<td>F</td>
<td>Second</td>
<td>Yes</td>
<td>Confident</td>
<td>Socially comfortable</td>
</tr>
<tr>
<td>Belle</td>
<td>21</td>
<td>F</td>
<td>First</td>
<td>No</td>
<td>Confident</td>
<td>Outgoing, Motivated</td>
</tr>
</tbody>
</table>

Jane was an 18-year-old female was in the second year of the transition program. Jane presented as very timid, especially around males. Jane had no prior formal interview experience. Anne was a 20-year-old female was in the first year of the transition program. Anne did not have any diagnostic records from her high school. Her teachers noted she had shown significant progress during her first year in the transition program. Anne had no prior formal interview experience. Carlitos was a 20-year-old male was in the second year of the transition program. Carlitos had participated in mock interviews in his high school transition program. Elana was a 21-year-old female was in the second year of the transition program. Elena has both ID and multiple personality disorder. Elana’s prior interview experience included informal mock interviews with her family and school programs. Finally, Belle was a 21 year old female was in the first year of the transition program. Belle was diagnosed with both ID and a language processing disorder. Belle had no prior formal interview experience.

Settings

This study took place in two locations. The first setting was TLE TeachLivETM virtual classroom laboratory, on the campus of a large, urban University. The TLE TeachLivETM lab served as the setting for participants to practice interview skills in a real-time mixed-reality setting. Participants took part in both baseline and intervention treatments in this setting. During baseline and treatment interviews, the participant was seated facing the television. This space is a windowless room with three beige colored walls and one green wall. A large projection screen was located slightly left of the center of the room, and was roughly 12 feet from the entryway. A 70-inch high-definition flat screen television suspended approximately three feet from the floor is placed in front of this screen for use in this study. A screened space adjoined the projection screen on the left-hand side and provided a divider for an on-site TLE TeachLivETM technician to assist in program operations. A logistics webcam mounted on the top of the projection screen allowed the interactor to view the participant during sessions. Speakers behind the screen enabled the interactor to hear what the participant said during sessions. Real time communication between the interactor and the participants occurred via Skype. The professional interactor was in control of the behavior of the avatar from a remote setting. The interactor was trained as an improvisational actor with three years’ experience working in the TeachLivETM lab. The second setting was a small classroom (15’x 21’ containing a round table and chairs) adjacent to the TeachLivETM Lab where coaching sessions were conducted following treatment interview sessions.

Skills targeted for instruction

An interview performance rubric that measured overt behaviors, verbal communication style and content was created for use in this study in consultation with an employee expert panel. The employee expert panel consisted of both Career Service professionals from the Office of Career Services at a large southeastern university and local business experts. The five participants were individually assessed on their ability to display behaviors from three domains: overt behaviors, verbal communication, and answer content. Specifically, the researchers were looking for the participants to display overt behaviors, such as eye contact, posture and, hand gestures, along with proper communication skills (those that did not include slang words, inappropriate language or grammar), the lack of distracting communication habits (such as “umm’s”, and other verbal patterns) and a loud and clear voice.
Researchers also looked for the interviewee responses to contain appropriate content that was positive and highlighted the participant’s abilities in response to the interview questions.

Participants were directed to the Office of Career Services where the Director of Career Services asked participants 11 randomly generated questions in a scripted, video-recorded mock interview. The responses and behaviors were noted and the researcher used the rubric to score the participants’ responses. The interviewer gave no feedback or rewards during pre-baseline assessment. All pre-treatment interviews were video-archived for purposes of monitoring and documenting treatment integrity.

Second, a non-experimental pre/post assessment of interview performance was used by comparing interview performance as scored on the rubric between the pre- and post-treatment live interviews. The rubric was completed in real-time during the interview by a trained member of the research team hidden from view of the participant and the interviewer (see Appendix A). The pre- and post-treatment interviews had no impact on the skills targeted or the intensity of the coaching as the intervention and evaluative rubric had already been designed by an employee expert panel.

Baseline assessment

An eleven-question interview addressed and measured the three constructs (overt behaviors, verbal communication style, and content of answers). Participants could earn a total of nine points per question, three points for overt behaviors, three points for verbal communication style and three points for the content of answer (Appendix A). Behaviors were recorded as either Proficient (P) or Non-proficient (NP). Proficiency was determined based on the absence or presence of a verbal and physical response and resulted in a score of either P or NP. One point was awarded for a P and zero points were awarded for a NP score. The use of a P or NP scale was developed and piloted by the lead investigator and employment interview experts in order to promote consistency based on scoring procedures that were well-defined. First impressions are considered to be important so whether the student greeted with a smile and introductory statement was counted as one point. The rubric consisted of a total of 100 possible points.

Research design

A multiple probe across days design (Gast & Ledford, 2010) was utilized to collect data in the TLE TeachLivETM lab. Data were collected across days in both the baseline and intervention phases of the study. Given the criteria established below for stable and predictable data, participants moved from the baseline to the intervention phase.

All five identified participants were brought into the baseline condition simultaneously. Treatment was staggered across participants based on the phase change criteria described below. If participants needed to wait before entering the lab, a lounge area with couches and desks was provided. Participants were instructed not to interact about the treatment or procedures during the research study. In order to ensure that participants did not interact between sessions about questions asked during the interview, an undergraduate research associate facilitated participant transitions between interviews and coaching sessions.

Baseline consisted of virtual interviews in the mixed-reality environment. Interviews consisted of 11 randomized questions. The participants did not receive coaching sessions during baseline. For each participant, a minimum of four data points were collected in order to establish stable and predictable data. A stable and predictable trend was defined as four data points which did not vary more than an average of 20 percent on the interview rubric (Gast & Ledford, 2010).

Prior to implementing coaching sessions, the lead investigator inspected the baseline trend of interview performance for all participants and determined that data were stable and predictable for Jane. When treatment was initiated for Jane, the remaining participants remained in baseline until Jane demonstrated a distinct pattern of data or six treatment sessions occurred. The second participant, Anne, entered treatment when visual inspections by the lead investigator demonstrated a change of slope and level in three data points for Jane. The slope trend forming a distinct pattern was used to transition a participant into the treatment phase. Visual analysis of baseline data for participants
two through five was repeated to determine if their data were stable and predictable, and, therefore, could serve as experimental controls for Jane. Kratchowill et al. (2010) state that evidence for causal relations can be established by visual analysis if the analysis can document the demonstrations of effect by measuring the consistency of level, trend, and variability within each phase. When a distinct pattern of data was demonstrated, Anne began intervention. Anne was chosen based on lowest level performance while demonstrating stable and predictable performance in her baseline interviews. Level, trend, and variability of all legs of the multiple probe design were considered in making decisions on phase changes (Gast & Ledford, 2010). When the participant reached criterion level of mastery (i.e., 80% for three data points in a row) or six sessions occurred, treatment for the participant could be terminated.

**Training sessions**

The treatment package comprised of a two-step intervention consisting of both virtual interviews within the TLE TeachLivETM environment and subsequent coaching sessions. This treatment was delivered as a package. No attempt was made to analyze the contribution of the separate components. Interviews in the TLE TeachLivETM lab began with a research associate leading the participant into the lab. Introduction to the treatment was scripted. Participants were introduced to Ms. Lowery, the avatar interviewer, and were seated at a small desk facing the screen. Ms. Lowery was seated at a desk in the virtual office and she was manipulated by the interactor who was located at a remote site. After the participant was seated, the interview began.

Interviews consisted of 11 scripted questions randomly selected via a random number generator from a bank of 27 questions. The interactor began the interview by stating “To begin, I would like you to give me a summary of your education and any work-related experiences you’ve had.” After the participant responded to this prompt, the interactor continued to ask questions in the order they were presented on the script. The interactor was allowed to ask one follow-up probe per question if needed based on defined criteria. Follow-up probes were only allowed in order to (a) clarify a concept (“Could you explain what you mean by that?”), (b) elongate an answer (e.g., “Could you tell me more about that?”), or, (c) repeat the question for the participant. Interviews took between 5-15 minutes. After the interview was complete, participants were escorted out of the lab by the lead investigator and accompanied to the coaching room by a member of the research team.

The second part of the treatment package consisted of the coaching intervention that was conducted immediately following each TLE TeachLivETM interview. Coaching sessions were based on mentoring and reflection and guided by both analyzing participant performance in the treatment interview and focusing on strategies to improve participant responses. Each session began with a brief introduction of the coaching session procedures. The coach followed a coaching script that consisted of eight discussion prompts (Appendix B) based on Layng’s (2007) study of successful communication during an interview. The coaching prompts were explained to the participants before the coaching sessions began so they were familiar with all the terminology used. Throughout the course of the coaching sessions, modeling behavior and participant rehearsal of correct behavior was allowed. Coaching included identifying correct and incorrect responses, probing errors made, and modeling responses as requested by the participant. Each coaching session lasted between 10-20 minutes depending on the participant.

**Generalization**

Fourteen to 21 days after completion of each participant’s treatment phase, he or she engaged in a live interview with a member of the employee expert panel to check generalization in a live setting. While the pre-treatment interviews were conducted by the Director of Career Services, the post-treatment interviews were conducted by the university’s Coordinator of Career Development. This was by research design to avoid participant familiarity with the interviewer from the pre-interview.

**Treatment fidelity**

Interactor training consisted of meeting with the lead investigator and other members of the research team to discuss the interview questions, the importance of fidelity regarding the order of those questions, and how to begin, conduct, and end an interview professionally. Training sessions followed an interactor script to make sure experimental
procedures were consistently employed. During the training, the interactor demonstrated 100% accuracy when asking questions in the correct order as evidenced through direct observation by the research team. During baseline and treatment sessions, accuracy of interview delivery was measured utilizing an interview checklist. A member of the research team observed and calculated fidelity on 30% of the interview sessions randomly selected throughout the study and all sessions were found to be 100% accurate.

Follow-up interview

The Office of Career Services personnel and authors provided a two-hour training session to the entire research team to address post interview coaching. In order to ensure the coaching sessions were administered correctly, the coaching prompts were provided to the research team and discussed. The coach performed a mock interview session by practicing the interview script with the research team in two practice sessions one week prior to the lesson.

Results

Evaluation of data included visual analysis of data points (via a line graph created in an Excel spreadsheet) collected for each participant throughout each phase (i.e., baseline, probes, treatment) of the research study. Results for each participant are listed in Figure 1 and explained below.

Jane

Jane’s baseline mean rubric score was $M = 26.8$ with a range of 21 to 29. After implementing the independent variable (i.e., combination of treatment interviews and coaching), Jane’s mean performance was $M = 57$ with a range of 37 to 68 over six treatment sessions and included a noticeable change in both level and slope from baseline to treatment. She finished with a high score of 68 out of 100 total points on the interview rubric. The rated scores on the rubric show an increase in Jane’s performance of targeted interview behaviors in a mixed-reality interview setting.

Anne

Anne’s baseline mean score was $M = 25.2$ with a range of 17 to 33 with a slightly increasing slope during the baseline phase. Visual analysis of Anne’s data demonstrated a change in performance when compared to baseline conditions with treatment scores showing a consistent increase in the level of performance as depicted by the accelerating slope. Anne had a family emergency and missed one and a half weeks of school following her third treatment. Upon returning to school, Anne’s performance stabilized at a much higher level during her last three treatment sessions. She ended with a mean score of 63.2 over the six treatment sessions.

Carlitos

Carlitos, the third participant taking part in the study, had a baseline mean of $M = 58$ with a consistently flat slope during baseline. His high score was a 63 during the baseline sessions while his low score was 49. After implementing the independent variable (i.e., combination of treatment interviews and coaching), Carlitos’ mean performance was $M = 78.7$. His interview scores ranged between 75 to 83 over six treatment sessions and included an increasing slope. Carlitos finished with a high score of 83 during the treatment sessions. The visual data provided evidence of the ability of Carlitos to improve his performance in a mixed-reality interview setting.

Elana

Elana recorded the highest mean performance of all participants during baseline ($M = 60.3$) and treatment ($M = 85.3$) phases. She participated in seven baseline interviews and six treatment sessions. Visual analysis of Elana’s baseline data demonstrated a stable and predictable trend with range of performance scores between 53 and 66. She recorded
a mean performance of 60.25 and a stable baseline increasing slope. After the phase change was implemented, a clear change in the level of performance from baseline to treatment was noted although the slope stayed the same between baseline and treatment phases. Her high score during treatment was 89 out of 100 possible points. Her final five interviews all scored in the 80’s demonstrating consistent performance above 80th percentile.

Belle

Belle had a range of scores between 11 and 55 in baseline sessions. She ended baseline with a mean of $M = 38.8$. Visual analysis of Belle’s data suggested a large change in both level and slope of performance throughout the baseline and intervention sections of the study. After her third treatment session, Belle missed one week of treatment as demonstrated in Figure 3. Belle completed treatment with a mean of $M = 69$ during her treatment sessions and a high score of 80. The rated scores on the rubric show an increase in Belle’s performance of targeted interview behaviors in a mixed-reality interview setting.

**Figure 1.** Interview scores recorded by participants

Pre-post scores in live settings

Non-experimental pre and post data were collected for participants who interviewed with a live representative from the University’s Career Services to address the second research question. The setting was a simulated office used by
Career Services to administer mock interviews. All five participants made marked improvements in their interview performance as measured by the rubric (see Table 2). All participants were exposed to the exact same number of treatment sessions (6) in the treatment phase and this conformity strengthens the internal consistency of the study.

<table>
<thead>
<tr>
<th>Participant</th>
<th>Pre-interview</th>
<th>Post-interview</th>
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<tbody>
<tr>
<td>Jane</td>
<td>37</td>
<td>58</td>
<td>19</td>
</tr>
<tr>
<td>Anne</td>
<td>41</td>
<td>59</td>
<td>18</td>
</tr>
<tr>
<td>Carlitos</td>
<td>44</td>
<td>90</td>
<td>46</td>
</tr>
<tr>
<td>Elana</td>
<td>53</td>
<td>83</td>
<td>30</td>
</tr>
<tr>
<td>Belle</td>
<td>28</td>
<td>67</td>
<td>39</td>
</tr>
</tbody>
</table>

Individually, Carlitos made the greatest gains (increase of 46%) in performance while Anne increased the least (increase of 18%). An analysis of the participants’ scores as a whole indicated that the mean gain was 30.4, a large improvement over the six-week timeframe of the study. Live interview performance, as scored on the same rubric used during the intervention, indicated improved performance for each participant, with a range of 18 to 46 points.

**Discussion**

The purpose of this study was to investigate if individual practice interviews with avatars in a mixed-reality environment combined with individual coaching impact interview performance of five young adults with intellectual disability (ID). The participants were five young adults with intellectual disability who attended a transition program for 18-22 year old students with ID on a college campus in a large, urban city in the southeastern United States. The participants were assessed on generalization and maintenance in a live, mock job interview. The intervention was demonstrated to be effective in improving the individual interview skills and behaviors within the mixed-reality environment, as well as generalization to the post-intervention follow-up interview.

There were many factors that impacted the results of this study. For example, Anne missed 1.5 weeks of school due to a death in her family. This incident delayed her participation within the treatment sessions and resulted in a slight loss of experimental control due to the absence. Given the delay in Anne’s participation, we implemented treatment with Carlitos immediately afterwards. Due to TLE TeachLivE™ lab time constraints, the assumptions of the research design were violated by not allowing the participants to stagger the baseline sessions. However, sufficient replication exists to suggest that the violation was not large enough to impact the overall results of the study. In addition, after Belle’s third treatment, she missed the school bus and, combined with spring break, had to miss one week of treatment. These events also resulted in a slight loss of experimental control and the missed treatment is demonstrated by the break in treatment scoring.

While it is important to note that interview performance increased significantly, it is also important to note that there is no validated score that insures employment or employability. However, we believe that the TLE TeachLivE™ and other virtual learning environments may be valuable for student instruction for multiple reasons. First, a trained interactor can represent a single individual (as used in this research study) or multiple people (as in a group interview or an audience of teachers) at one time. Having a student practice interviews with different “people” every day is valuable for practicing social skills. For teachers, this can be a seamless and efficient way to offer instruction with various people. Second, the ability to offer instruction in multiple environments (a classroom, the community, a workplace office) provides teachers the ability to “take” their students into new environments without ever leaving the classroom lab. Third, there is research to suggest that a virtual learning environment like TLE TeachLivE™ has multiple applications for schools from training staff to individual student instruction (Dieker et al., 2014; Dieker, Grillo, & Ramlakan, 2011; Vince Garland, Vasquez, & Pearl, 2012).

Our findings suggest interview performance in both live and virtual settings improved after the innovative treatment package consisting of virtual interviews and coaching. Smith and Matson (2010) report on the difficulties of recognizing social cues when in job interview settings while Bouck (2010) encourages educators to explore creative ways of reaching individuals with ID. Similarly, this package has shown that the use of avatars, virtual supports, and coaching can provide a relevant intervention for young adults transitioning into employment. In addition, the use of
mixed-reality can help individuals with ID to self-identify their own communication subtleties and overt behaviors that may impact their performance.

**Limitations**

This particular intervention requires trained personnel, dedicated space, and certain technical components as detailed in the methodology. Personnel include trained career service personnel, educators with experience in transition, and an interactor trained in improvisation, education, and psychology. Dedicated space included two separate classrooms within the same building. One room was the TLE TeachLivE™ lab and the other was used for coaching sessions. The technical components required included specific software, namely, the TLE TeachLivE™ system and Skype. The hardware included cameras, speakers, and microphones. Technology can falter from time to time and there were two days when the sessions had to be delayed by approximately 30 minutes so that the TLE TeachLivE™ system could be rebooted and tweaked by study personnel. There were also four interviews that were not recorded due to camera failure. However, all interviews were scored in real-time and the technical issues did not impact the study in any way.

Non-technical limitations to the present study should also be taken into consideration. First, results may not be generalizable based on program and geographic location. The participants in this study were volunteer, mature-age university students who had a specific interest in improving their interview performance or gaining employment and may not be representative of the general population and persons with ID. Additionally, all participants were part of the same class in the same transition program. This homogeneity limits the variability of the participants and enhances experimental control by having participants that are “functionally independent but also functionally similar” (Gast & Ledford, 2010, p. 281). However, this homogeneity may also limit generalization to individuals labeled as ID but with different skill sets due to various educational backgrounds.

Second, social skills and self-advocacy, in particular, are important for individuals with disabilities so they become involved in stating their workplace needs and “selling themselves.” These skills are vital in a live interview setting and in the workplace. However, social skills are only one of several barriers that limit individuals with ID from securing successful employment. While individuals with disabilities who possess strong social skills may have more success in securing and maintaining employment, social skills alone may not compensate for less than adequate academic preparation or other’s perceptions and treatment of individuals with ID in the workplace. Other factors such as dress, personal grooming, hygiene and punctuality that may be judged in determining interview success (e.g., Allen, 1994; Brown, 2000; Kissane, 1997; Stewart & Cash, 1997) also were not addressed in this study.

Third, two participants missed their scheduled time in the lab due to a family emergency or transportation issue. The sessions were made up when the participants returned to school, however, there was a gap in treatment for each participant. In addition, the post-interviews were held on-campus in a formal, quiet setting with a professional in professional dress. This may not be consistent with the conditions of an entry-level interview.

**Conclusions and future research**

The use of mixed-reality environments and coaching to provide instruction for individuals with disabilities is innovative and has many possibilities for further research. Mixed-reality environments can be seen as a medium for instruction and practicing behaviors while the coaching can be seen as the instruction itself. The particular type of instruction that a teacher uses (e.g., direct instruction, constructivism) could be used in any setting. What makes mixed-reality unique is the opportunity for individuals to practice these skills in a setting that is realistic but does not result in harm to the participant or the “practice partner” since they are not real (Dieker et al., 2008).

In regards to this study, it will be interesting to investigate if interview practice in a mixed-reality environment is the most significant factor in altering interview performance or if the utilization of coaching adds a dimension that allows participants to increase or decrease their performance. The effect of each variable could be analyzed by comparing interview performance after practice interviews with no coaching to interview performance after coaching sessions with no practice. The combination of variables was successful in this study but to what degree each component was responsible for increased performance would need to be identified by further research.
Future research may also be conducted to test the reliability and compare the validity of other evidence-based models of instruction (e.g., direct instruction, video modeling). For example, would results improve if we added a video modeling component to instruction? Would results occur sooner or generalize differently if a different type of instruction is used? Research may also be useful on the combination of video modeling and coaching before practicing in the mixed-reality environments. Leishman (2004) encourages us to be proactive when considering the use of new media in education. This research proves to be an important first step in exploring the viability of mixed-reality environments in training individuals with ID for employment interviews. However, it is also important that more refined research be conducted to explore the impact of individual factors on interview performance and the feasibility of combining those with training in mixed reality environments.

References


Harrington, T. F. (1997). *Handbook of career planning for students with special needs*. Austin, TX: PRO-ED.


## Appendix A

### Interview Rubric

<table>
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<tr>
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<th>Int. Q</th>
<th>Q2</th>
<th>Q3</th>
<th>Q4</th>
<th>Q5</th>
<th>Q6</th>
<th>Q7</th>
<th>Q8</th>
<th>Q9</th>
<th>Q10</th>
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**Verbal Communication**

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**Content of Answers**

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**Total Score**

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**Student Name** ___________________________

**Scored By:** ___________________________

**Date:** ________________

P=Proficient/NP=Non-Proficient
Appendix B

Investigator Script for Coaching Session

This coaching session is intended to improve interview performance. You are not being graded on how you answer these questions so please feel free to answer them honestly and completely. You can also ask any questions if you do not understand a concept. Thank you again for your participation. Do you have any questions before we begin?

Okay, I am going to ask you a few questions about your performance in the practice interview today.

1. On what parts of interview did you perform well?
2. What mistakes did you make during the interview?
3. What questions surprised you?
4. How did you handle questions that surprised you?
5. What distracting physical characteristics might you have used during the interview?
6. What verbal ticks or patterns did you use that could have been distracting for the interviewer?
7. Do you feel that the content of your answers was appropriate?
8. What did you learn about interviewing today that can help you improve?

Thank you for participating today. You did a great job.
The Role of Social Media Tools: Accessible Tourism for Disabled Citizens

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ABSTRACT
Knowledge sharing becomes important to accomplish digital citizenship. Social media tools become popular to share and diffuse the knowledge in the digitalization. This social media learning and knowledge sharing platforms provides accessibility to the services within societies especially for disabled citizens. This research study aims to evaluate the role of social media tools on tourism services of the country in respect to the perceptions of disabled people. Furthermore, the research study examines the web usability and accessibility of the services to the citizens within the society. In this respect, mixed method was conducted to gain reflections of disabled people on tourism services and social media tools for equality of life standards. For evaluating the current situation of the web usability and accessibility of the societal and institutional networking, analysis was done to set standards of the research context. Orthopedically disabled people participated in this research study that they were selected purposely due to having skills on using social media. This research study showed that orthopedically disabled people used social media and networking for expanding their knowledge. They have a firm belief that social media and networking is the facility for removing barriers of social and institutional activities in society. In addition, there are little facilities on tourism services to be used in social media and networking. Furthermore, web pages of the societal and institutional services are not satisfactory and accessible for the all disabled citizens. The study puts forward to provide extended report on web usability and accessibility of services for the welfare of the disabled citizens within the society.

Keywords
Accessibility, Social media tools, Tourism services, Web accessibility

Introduction
Information and technology becomes bridge to foster usability, accessibility and equality of the citizens. Societies has intensified need to gain services for accessibility to the travel and tourism opportunities that this requires information, effort and desire. Especially, people with disabilities in the world need for easy access to proceed their lives in equality and usability standards. As travel is a key for continuing globalization to gain information for the development, tourism activities of the societies play a great role in providing accessibility and broadening accessibility for all citizens. For the welfare of the society, accessibility is crucial element for the disabled citizens where literature pays attention on physical and web accessibility for societal and institutional services (Chadwick et al., 2013). In a concrete practice of tourism services and accessibility, in 1980 Manila (Philippines), tourism and accessibility were first merged through Manila Declaration, and later pursued by the World Tourism Organisation. This indicates that tourism become an essential right and crucial for human development. It is a way of social development of disabled citizens and welfare of the society upon tourism economy. This significant right should be supported by governmental policy and needs to be recommended as a regulation for tourist services. There is a concrete attempt for the tourism services accessibility for all citizens. Significantly, web technologies and services within a term of unobstructed information technologies services for social and academic development of disabled citizens become vital empowerment of caring the needs and expectations of those citizens for gaining benefit from societal and institutional services within the society. Facilitating access in terms of infrastructure and tourism services for disabled people is the part of accessible tourism (Alén, Domínguez, & Losada, 2012). In this respect, activities with technology enhanced environment are crucial for the accessible tourism.

Accessible tourism covers a variety of activities within free time to tourism. It relies on making people with restricted capacities and fully integrate their functional and psychological thoughts and actions for the individual satisfaction and social development (Alén, Domínguez, & Losada, 2012). Those accessible activities and technology enhanced services provide inclusion and socialisation which are very significant development indicators for disabled people. Being part of the society and active involvement to the societal and institutional services becomes primary right of the disabled citizens within all societies. In addition, UNWTO (2005) points out that accessible tourism is a collaborative process that provides people with access and mobility. This makes equity and dignity through the
delivery of tourism services. Within the digital age, technology supported attempts also effect preferences and choices of all individuals which technology and social media also shape choice. Furthermore, changes through information technology and global world standards activate the travellers to become more independent, experienced, and flexible for accessible and reliable information (Buhalis, 1998; Buhalis et al., 2011).

Domínguez et al. (2015) adds a value on the work to incorporate disability within tourism policy, planning and development. In addition, developing countries need creation of policy to support tourism services and institutional services through proactive implementation on web accessibility within a master plan.

The report of the European Union argues that tourism industry has started to pay attention on a significant consumer group as disabled tourists. Furthermore, social media and networking tools create alternative platforms where people interact freely and easily exchange information (Buhalis et al., 2011; Fotis et al., 2012; Gretzel et al., 2008). Tourists are having more control over their travel decision making process and shaping the tourism related businesses through online tools (Cox et al., 2007). Social media plays a great role to establish a travel product for the disabled people.

Upon the limitations on accessibility of tourism, societal and institutional services for disabled citizens (Eichhorn et al., 2008), this study aims to reveal the role of social media in accessible tourism for disabled citizens. Furthermore, the study aims to reveal the current practice of societal and institutional services in terms of web accessibility for disabled citizens which could be the base for the welfare of the society in developing policies and regulations towards unobstructed society.

Web accessibility in Europe and how web content can be made more accessible for disabled people is explained in the Web Content Accessibility Guide (WCAG) 2.0 developed by W3C. Accessibility involves many disabled people as well as visual, hearing, physical, speech, perception, linguistic, learning and neurological disabilities. Although, this guide is as comprehensive as possible; it does not provide any possible solutions for the needs of people from all groups and with different levels of disabilities. Additionally, the information provided in the guidebook enable a more accessible content for the elderly and general population.

People with disabilities face various problems in their social life because they cannot be added to an adequate extent. The context of Northern Part of Cyprus has many barriers to provide services of enhancing life standards. The reports of Ministry of Education showed that disabled people are living limited in both using societal and technological facilities. Education for the awareness and applications will become strategic actions to remove barriers of disabled people. In this respect, efforts to increase participation of disabled people in social life through evaluating tourism regulation and accessing web services.

Web accessibility is not only dependant on accessible content but also on the accessibility of Web browser and other user interfaces. Software tools also have an important role in web accessibility. The analysis of websites based on four main principles and suggestions are provided (See Appendix I). In this respect, WCAG 2.0 has been used to evaluate current situation of practices in Northern part of Cyprus for considering as a result of working with people and organizations to form common standards in web content accessibility.

This research aims to evaluate the role of social media tools on tourism services of the country in respect to the perceptions of disabled people. It is examined the web usability and accessibility of the services to the citizens on societal and institutional services. The following research questions were revealed within the research process:

- How do disabled citizens perceive the role of social media tools on tourism services?
- To what extent are web pages and services of societal and institutional levels usable and accessible?

**Methodology**

The research has mix method nature which it has sense of qualitative and quantitative patterns. In this respect, the procedure of the research process cover mix research framework. Upon real world practice; social and historical construction, patterns and process of interaction among individuals provide a framework of research procedure (Creswell, 2005, p. 9). The voice of participants provides raising consciousness and meanings, patterns as part of inquiry to construct a picture of issues that investigated. Within a transformative process, there is convergence, integrated, combined nature of qualitative and quantitative manner.
Research procedure

In quantitative sense of this research process, questionnaire was implemented. The questionnaire included; demographics, work status, hours spent using social media, frequency of travelling and holiday planning to reveal the support of technology in travel and tourism activity of the disabled citizens. The SPSS 17 were used for data analysis which frequencies, t-test and ANOVA are considered to give detailed analysis on how disabled citizens perceive the role of social media tools on tourism services. In line with questionnaire and the framework of quantitative procedure, qualitative research included open ended questions through self reports which cover asking about benefits using social media and role of the social media for using tourism services were employed. This procedure supports how disabled citizens perceive the role of social media tools on tourism services. Thematic analysis was used to analyze qualitative data based on key themes (Creswell, 2005).

Furthermore, the web usability and accessibility checklist was implemented to state the current situation of societal and institutional services including higher education institutions, municipalities, post offices, etc. Web Content Accessibility Guide (WCAG) 2.0 developed by W3C was used to set the current situation of services. Nine web sites were analyzed and report was revealed upon international standards.

Research context and participants

The research context covers Northern part of Cyprus as a small island. In this context, although initial stage has been started, world standards are being tried to be followed for the welfare of the disabled citizens. Tourism and education are the fundamental economic support for the country which has untouched beauty, security however there are limited infrastructure for the disabled citizens in all aspects of the society. Increasing the welfare of the society relies on equality, opportunity in all services for all citizens. Therefore, there is significant need to consider development and improvements in tourism and education for disabled citizens. Although there is a need to do further attempt on welfare of those citizens, there is also limited evidence and academic report, studies in relation to that research focus. Unobstructed technologies in education and also in tourism help social inclusion of those citizens which those academic activities are held from 2013 up to date. In 2015, the higher education consortium was done to discuss and propose solutions upon the use of technology in social and academic life of the disabled citizens. Although there are limited studies even in academic agenda, this study will be the first practical implication within the country and it will also contribute to extend knowledge on technology supported services in tourism and education for disabled learners. Significantly, web usability and accessibility of the services were not designed upon considering disabled citizens that this study becomes a milestone step to set the situation and delegate how web services can be accessible and useable.

20 orthopedically disabled citizens participated to the research that they were selected purposively upon having skills on using social media. These participants volunteered to be part of this study and researchers give guarantee to keep confidentiality during the research process. Furthermore, web services were analysed to represent all institutional and social services for disabled learners within this study. Therefore, nine web pages were selected purposively which includes ministries, municipalities, higher education institutions and post offices, etc.

Findings

Participants in the scope of research are given in Table 1. The distribution of demographic characteristics are as follows: Participants who participated in the study 52.6% of female, 47.4% were men, and 18 -25 years of age of 31.6%, 36.8% between 26-35 years of age, 21.1% of the 36-45 years, 5.3% of the 46-55 and 5.3% is located in the 56-64 years.

When the participants who enrolled in the study are examined education they are enrolled; 10.5% of master’s degree, 26.3% of bachelor’s degree, 36.8% of high school. It is seen that the junior high school of 26.3%.
In the study, 89.5% of the participants from North Cyprus, 10.5% of Turkish citizens. 36.8% of participants are married and 63.2% single.
Table 1. Participants’ socio-demographic characterises

<table>
<thead>
<tr>
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<th>Percent (%)</th>
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<tbody>
<tr>
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<tr>
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</table>

Data were analyzed in three headings; Travel behaviors, using social media and role of the social media and networking for using tourism services

Travel behaviours

For analyzed participants travel behaviors, two points were gaining importance. These are frequency of travelling, reasons if they do not travel (see Table 2).

Table 2. Travel behaviors

<table>
<thead>
<tr>
<th></th>
<th>Frequency (n)</th>
<th>Percent (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency of travelling</td>
<td></td>
<td></td>
</tr>
<tr>
<td>None</td>
<td>3</td>
<td>15.8</td>
</tr>
<tr>
<td>1 times</td>
<td>1</td>
<td>5.3</td>
</tr>
<tr>
<td>2 times</td>
<td>9</td>
<td>47.4</td>
</tr>
<tr>
<td>4 times and over</td>
<td>6</td>
<td>31.6</td>
</tr>
<tr>
<td>Reasons not to travel</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Income levels</td>
<td>3</td>
<td>15.8</td>
</tr>
<tr>
<td>Transportation difficulties</td>
<td>2</td>
<td>10.5</td>
</tr>
<tr>
<td>Unable to travel alone</td>
<td>3</td>
<td>15.8</td>
</tr>
<tr>
<td>None</td>
<td>11</td>
<td>57.9</td>
</tr>
</tbody>
</table>

47.4% of participants travelling in a year two times. Additionally, 57.9% participants stated that they don’t have obstacle for travelling to the stresses. Second high percentages are income levels and unable travel alone. Both of them have 15.8%. The other interesting point is 84.2% travelling at least once times in a year. Upon responses of participants, over of the half prefer mass tourism (sea, sun, sand) in their holiday.

According to Table 3, it is determined that there is a statistically significant difference between total points of travel frequency and gender. The effect of diversity is then made with the purpose to determine, according to Tukey test results, when the time spent increase social media, effect of social media using increasing for holiday choice.
Table 3. Comparing travel frequency and gender

<table>
<thead>
<tr>
<th>Gender</th>
<th>N</th>
<th>X</th>
<th>S</th>
<th>F/t</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Female</td>
<td>10</td>
<td>1.50</td>
<td>0.70</td>
<td>0.000</td>
<td>.00</td>
</tr>
<tr>
<td>Male</td>
<td>9</td>
<td>5.00</td>
<td>0.00</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 4. Comparing age and duration of travel

<table>
<thead>
<tr>
<th></th>
<th>Sum of squares</th>
<th>df</th>
<th>Mean square</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between groups</td>
<td>48.812</td>
<td>4</td>
<td>12.203</td>
<td>12.457</td>
<td>.000</td>
</tr>
<tr>
<td>Within groups</td>
<td>13.714</td>
<td>14</td>
<td>0.980</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>62.526</td>
<td>18</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

According to Table 4, it is identified that there is a statistically significant difference between total points of scale according to participants’ age and duration of travel ($p < .05$). This difference arisen between those participants, who ranging between 18-25 and 36-45 age groups.

Using social media

First of all, the questions for use social media were collected in two points. Most used social media sites and spending time in these sites. 63.2% participants use Facebook, twitter and Instagram in their life. 42.1% participants spend approximately 2 hours in a day on social media sites. This also shows a considerable amount of time spent on social media (Table 5). Participants clarified what they knew about social media and what their perceptions from social media. Almost all participants considered social media and networking as a support to experience of their self-development and education. When asking their information and knowledge level about social media using, most of them indicated that they have a good level of information and knowledge.

Table 5. Using social media

<table>
<thead>
<tr>
<th></th>
<th>Frequency (n)</th>
<th>Percent (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Most used social media sites</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Facebook / Twitter / Instagram</td>
<td>6</td>
<td>31.6</td>
</tr>
<tr>
<td>Google / YouTube</td>
<td>3</td>
<td>15.8</td>
</tr>
<tr>
<td>Diger</td>
<td>1</td>
<td>5.3</td>
</tr>
<tr>
<td>Time spend in social media</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0-1 hours</td>
<td>3</td>
<td>15.8</td>
</tr>
<tr>
<td>1 hours</td>
<td>4</td>
<td>21.1</td>
</tr>
<tr>
<td>2 hours</td>
<td>8</td>
<td>42.1</td>
</tr>
<tr>
<td>3 hours</td>
<td>1</td>
<td>5.3</td>
</tr>
<tr>
<td>4 hours and over</td>
<td>3</td>
<td>15.8</td>
</tr>
</tbody>
</table>

Table 6. Comparing subscale points of using social media according to gender of participants

<table>
<thead>
<tr>
<th>Gender</th>
<th>N</th>
<th>X</th>
<th>S</th>
<th>F/t</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Female</td>
<td>10</td>
<td>2.00</td>
<td>0.81</td>
<td>0.205</td>
<td>.00</td>
</tr>
<tr>
<td>Male</td>
<td>9</td>
<td>3.77</td>
<td>0.97</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note. $p > .05$.

In Table 6, comparison of using social media and gender subscale points regarding socio-demographic characteristics of community within the scope of this research were given.

It is stated that there is no statistically significant difference between total points of public service and environment subscale regarding gender ($p > .05$).

There is a statistically significant difference between age and time spending in social media in Table 7. Young participant spend more time than middle age and older group of participants.
Table 7. Comparing age and time spent in social media

<table>
<thead>
<tr>
<th></th>
<th>Sum of squares</th>
<th>df</th>
<th>Mean square</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between groups</td>
<td>23.419</td>
<td>4</td>
<td>5.855</td>
<td>16.050</td>
<td>.000</td>
</tr>
<tr>
<td>Within groups</td>
<td>5.107</td>
<td>14</td>
<td>0.365</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>28.526</td>
<td>18</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Role of the social media tools on tourism services**

Upon comparison on participants’ travel behaviour and rate of the using social media, they spend at least one hour at social media in a day. So, they easily access travel services and opportunities from social media. For analyzed that role of the social media and networking for using tourism services asked questions (Table 8).

Table 8. Role of the social media and networking for using tourism services

<table>
<thead>
<tr>
<th></th>
<th>Frequency (n)</th>
<th>Percent (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Awareness of travel programs</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Travel Agency Web Sites/Facebook Pages</td>
<td>11</td>
<td>57.9</td>
</tr>
<tr>
<td>From friends and Relatives</td>
<td>6</td>
<td>31.6</td>
</tr>
<tr>
<td>Official Organizations /Associations</td>
<td>2</td>
<td>10.5</td>
</tr>
<tr>
<td>Booking of travel</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Travel Agency</td>
<td>5</td>
<td>26.3</td>
</tr>
<tr>
<td>Internet</td>
<td>7</td>
<td>36.8</td>
</tr>
<tr>
<td>Friends/Relatives Help</td>
<td>7</td>
<td>36.8</td>
</tr>
</tbody>
</table>

Table shown that 57.9% participants give their decision for arrange travel programs, they follow travel agencies web sites and Facebook pages. Afterwards, they book their holiday from travel agencies and web sites. Most of participants are active use of social media but they do not have enough knowledge and information using for tourism services.

Upon the quantitative research findings, qualitative research findings supported the same consensus on the role of social media tool for tourism services and preferences.

**Web accessibility and usability**

Upon WCAG test based on W3C (See Appendix I for principles), 211 potential problems were detected as a result of web services analysis for the disabled citizens. Nine web services are evaluated in relation to reveal the importance of technology supported services as a path in helping to disabled citizens to access and use societal and institutional services. Within a frame of social learning theory within the research process, web services were evaluated how they are effective and accessible to provide social inclusion of those citizens with the support of technology. Nine web services were considered as part of this study to reveal general spectrum and insights of services. Higher education institutions, post offices, municipalities are part of this analysis which listed statements reveal as common problems in web services:

- Image texts are not empty but texts are not defined appropriately;
- The name of the visual is same with descriptive information;
- Image title information and the image are not decorative;
- Indicator information in the tables were missed;
- Indicators are not appropriate;
- Check box closing positions are not appropriate;
- Radio buttons are not appropriate;
- Tables needs introduction elements;
- Some introductory statement used colours only;
- JavaScript were used alone;
- Script screens cannot be accessed via keyboard;
- Flashes involves flickers;
• Link colours and link descriptions are insufficient;
• Site maps are not provided;
• H1 and H2 titles were not defined; and
• There are problems with navigations.

Discussion and conclusion

Social media tools provide web based practice that fosters engagement (Lu & Churchill, 2014). Social networking is used a tool in different fields and practices (Hayes, Ruschman, Walker, 2009; Priestley, Waddington, & Bessozi, 2010; van Riper et al., 2013; Rohn, 2013). The common merits of social media in different studies that it provides participation, learning and connection. In this respect, it plays a great role for disabled people to provide inclusion and development in their life.

Knowledge sharing can be accomplished by the use of social media tools and create an atmosphere of connection on the diffusion of knowledge. Social media is a source of support and awareness on the lives of disabled people and enhances their life based on equality. Citizenship becomes shaped by digitalization. This provides development for all citizens and requires right to reach all services within the society, especially for disabled people. In this respect, social media tools put forward to raise awareness on the issue of accessibility for disabled people in different aspects.

Social media tools facilitate accessibility to reach out information, people through networks and make encouragement for disabled people to put their voices on their personal and professional development. Societies have started to provide accessibility to disabled people in their education and tourism facilities. This shows how the integration of technology makes life easier especially for disabled people for the welfare of the society. In addition this shows how technology crosses borders on differences among the features of people.

This research study sheds light on the accessibility of tourism services by social media tools and gives insights on perceptions of disabled people on accessible tourism. Furthermore, study reveals the current situation of societal and institutional services on web usability and accessibility to further set policy and improvement. As there is a gap in practice and theory about accessible tourism and the role of social media tools, this research study underlines the experiences of disabled people to set situation analysis of context for the welfare of the society. It is seen that individualistic efforts was done for tourism services where there is an intensified need to focus on accessibility in web services and tourism services of the country within the participatory manner.

References


Appendix I

Four main principles should be implemented in order for website content to meet accessibility criteria. These principles are: “Perceptibility”; “Usability”; “Intelligibility” and “Validity.” Each principle has its own sub-titles. Let’s briefly review those sub-titles:

1. *Perceptibility*: The most important feature on a page is its perceptibility by the user. Text, links, tables, images and other components of a page should be easily understood by the user.

1.1. The non-text content of the page should provide alternative texts and users should be allowed to turn these sections into speech, Braille, large letters, symbols or a more simple language. In other words, everything that is non-text format should be provided with an electronic equivalent.

1.1.1. Non-text content: If the non-text content is a form that needs to be filled by the user, it should have a name. If it is an image or a logo, it should have text explanation beneath the image or the logo. If the content is only a video or an audio feature or a test or exercise that cannot involve text; it should have a text tag explaining what it is. If the aim of the web content is to make sure it is read by a person and not a machine, like entering the code in the image; alternatives that appeal to different senses should definitely be provided. In other words, if it is asked to enter the characters in the image; an alternative that allows listening these characters or numbers should be provided.

1.1.2. Figure and graphic definition: Text definitions called longdesc should be put on the page for graphics and figures. At least, sub or titles text definitions of such components should be provided.

1.2. Alternatives for multimedia should be offered. Alternative ways for visually or hearing impaired people to understand audio or visual components should be used. Using subtitles or sign language in audio components for people with hearing disabilities; using audio or textual descriptions for videos can be beneficial.

1.3. Content should be introduced in alternative ways without losing any meaning.

1.3.1. If information is shown with a different colour or symbol; its text alternative should be provided as well. For example, required fields to be filled should be indicated with “*” symbol.

1.3.2. If the function of a button is determined by its dimension and location; this should also be indicated with text tag. For example, if the forward link on a research is indicated with a green arrow on the bottom right corner of the page, this should also involve a text tag saying “forward” or “next.”

1.4. It should be made easier for disabled people to differentiate the fore and background of the page.

1.4.1. If the text and links on a page are differentiated by colours; other visual tools for people who experience problems with seeing colours should also be used.

1.4.2. If there is an automatic sound that goes on for more than three seconds once a page is opened; a mechanism for stopping or reducing that sound without disrupting the system should be provided.

1.4.3. There should be colour contrast between the links to be read, text and text image and the background of the page. This will allow more perceptibility for users with low-visual abilities.

1.4.4. The text that is difficult to see on the page should be enlarged or made smaller to a certain degree without needing an assisting technology.

2. *Usability*: In addition to the perceptibility of the page content; being able to click the desired spots easily, access the desired section of the page; or filling in a form on the page freely is also equally important.

2.1. All functions should be accessible through the keyboard.

2.1.1. All content on the web page should be allowed to be done with the keyboard. In other words, the spaces that could be clicked, links and form fields should be accessible via the keyboard.

2.2. Disabled people should be given sufficient time to read the page content easily.

2.2.1. Timing: If the content of a page is automatically updated at certain intervals, or is there is a given time for filling in a form; users should be allowed to turn off this timing or increase the timing to its ten times.

2.2.2. Pausing: Users should be able to pause the moving, blinking, floating or automatically updated content.

2.2.3. When the user is not able to complete a process due to time limitations and returns to the form; the previously filled information should not be lost. Disabled users can be slower with filling in various forms and thus, get timed out. Once a process cannot be completed due to such conditions, time problems will not be experienced if the previous data is not lost.
2.3. Web content should not cause any seizures. Research shows that content which blinks more than twice in a second leads to seizures on people who have difficulty concentrating.

2.4. Arrangements should be made for users to browse through the page freely, easily access the sections they want and understand where exactly they are.

2.4.1. Skipping the repeating sections: The user should be able to skip the repeating sections once he clicks different links on the same page and access the main content. For example, when a user clicks a news link, he should be able to access the news heading directly through the keyboard. A link that would skip the repeating can be put in order to enable this feature. Sections on a page can be rightly titled or main page links that would lead directly to the sections can be put on top of the page.

2.4.2. Descriptive page titles: The titles on the pages should clearly describe the page content. For example, the title of this document is Web accessibility.

2.4.3. Descriptive Link Tags: The tag of a link that we click on the page should be appropriate for the content we would reach once we click the link. Thus, users can decide whether to open a page or not by looking at the name of the link among the link list provided by the assisting technologies. Also, it is better to use a descriptive tag statement like “click to download web accessibility document” rather than only “click” on any section of the page.

2.4.4. Alternative ways: It would be beneficial to use more than one way to reach page contents such as using links, list of contents or site map.

2.4.5. Descriptive tag: The tags of the titles, frames and tables on a page should give clues to the user about the content of those sections.

2.4.6. Table accessibility: The row and column relation of the tables on a page should be arranged correctly and within logic. Table summary should be provided by using “summary=” code at the beginning of the tables.

2.4.7. Section titles: If the long documents, especially, involve various sections, sub-sections and topics, these parts should be organized hierarchically at levels starting from H1 to H6. For example, main section titles can be at level 1; sub-section titles can be at level 2 and the topic titles of these sections can be at level 3.

3. **Intelligibility:** In addition to perceptibility, it is also very crucial that web content and its codes are understandable by the user and the assisting technologies.

3.1. The language of the web page should be defined by the page writer with codes. Also, if there are main sections with a different language on a page; these should also be identified by the page author. Hence, user tools understand the language of the page by looking at the web code and the necessary synthetic sound for the user is provided.

3.2. Web pages should look and be used in the way assumed by the users. Unexpected automatic changes on the page when a form is being filled or a choice button is clicked can make it more difficult to complete the process.

3.3. A help mechanism should be provided for users to realize and show how to correct their mistakes when filling in forms. Disabled users, especially, have higher chances of making mistakes as they cannot control the whole page. Mistakes during an application, making reservations or payment processes can lead to negative outcomes. Thus, users should be informed about what mistakes they made and how they can correct it before submitting the form. Additionally, users should be allowed to review the form before submitting and given a chance to correct their mistakes.

4. **Validity:** Web content should be reliably interpreted by the user tools involving assisting technologies.

4.1. Adaptability with the user tools of today and future involving assisting technologies should be at the highest level. At this point, it is important that web contents use the standards defined today and not use the traditional codes unknown to the assisting tools of today and the future.

4.1.1. Reviewing: The starting and finishing points of the codes on web pages should be defined according to formal regulations. If a code has been opened for a list or title level, it must be closed. That is the only way to allow user tools to review and page and inform the user accurately.

4.1.2. Name, Roles and Values: The names, values and functions of the form sections on a page, frames and all components of user interface should be presented in a standard way that could be interpreted and programmatically notice changes by the user tools.
The following results have been gathered after reviewing the 60 features under the instructions of the 4 principles in the WCAG guidelines.

**Principle 1: Perceptibility – Information and user interface components should be easily perceived by the individuals.**

12 features in terms of accessibility have been reviewed and 3-4 features have been mentioned although they were not sufficient. However, many instructions regarding the perceptibility of the web page for visually-disabled people could not be applied.

**Principle 2: Usability – The user interface components and navigation should be usable.**

When the site was reviewed according to the instructions under this title; it was observed that none of the instructions of this principle were applied.

**Principle 3: Intelligibility – User interface components and information should be understandable.**

When the site was reviewed according to the instructions under this title; it was observed that none of the instructions of this principle were applied.

**Principle 4: Validity – The content should be valid enough to be perceived by several user software as well as the user assisting technologies.**
ABSTRACT
What are the boundaries between traditional and new media, between ability and disability, and between the artist and the processes for making art? This article reports findings from a study of tablet devices as media for self-expression and visual storytelling by adults with intellectual disabilities and examined whether or not art-making processes were altered by the use of tablet devices when compared with the use of more traditional paper-based media. Using McLuhan’s tetrad as an analytical lens we identify processes simultaneously altered as users engaged with tablet devices. Social interaction and self-initiated communication were observed when tablets were used to create art.

Keywords
Tablet devices, Intellectual disabilities, Education technology, Visual storytelling, Tetrad

Introduction and research purpose
The study of digital and interactive information and communication technologies – so called “new media” – provides opportunities to reflect on several aspects of engagement; whether the focus is on users, technologies, or both – issues of participation, mediation, and perception can be meaningfully explored. Moreover, broader questions arise when considering the shifts in socio-technical arrangements that arise as consequences of new media in different contexts, and when used by diverse groups of people. Questions include, what are the boundaries between the user and the device (Latour, 2012; Suchman, 2006; Orlikowski, 2002; Star, 1989); between traditional and new media (Marvin, 1988; Jenkins, 2006; Bolter, Grusin, & Grusin, 2000); between the information literate and the illiterate (Spitzer, Eisenberg & Lowe, 1998; Lewis & Jhally, 1998; Jones & Flannigan, 2006); and between ability and disability (Harlan, 1993; Sutherland, 1997; Barnes, 2003; Peppler & Warschauer, 2011)? This article reports on a comparative media study of adults with intellectual disabilities who used tablet devices for visual storytelling, and explores the role of sensory perception in boundary explorations.

Science and technology studies (STS) scholars have focused on the roles that technologies play in providing platforms for participation and inclusion. Moser (2006) employs feminist theory to explore how technologies contribute to processes of making, unmaking, and reproduction of definitions of disability. Notions of power and control are highly integrated when examining technology use, the disabled, and the disenfranchised. In the history of the evolution of digital technologies from pre-industrial revolution to more recent times we observe that many times technological practices transferred from communities of experts to less skilled communities unwittingly, and when this occurs there is the potential for an opening up of the status-quo, further potential for power shifts, and consequently shifts in the ways that we understand the social order and each other (Innis, 2007; Marvin, 1988; Ling & McEwen, 2010). However, as Goggin and Newell (2003) argue these potentialities do not always lead to the types of participation from the (dis)abled as we could imagine and often new media implementations reinforce existing social structures, particularly when viewed in an abled-disabled comparative dichotomy.

The curiosity at the heart of this research is less about issues of power-as-agency as it is about power that may arise via the process of making art using technologies – instead of a comparison between abled and disabled people; we focus on those with disabilities and compare instead the media themselves. We conjectured that there is a relationship involving artistic expression, specific forms of technological mediation, and communication, experienced by persons for whom communication is impaired through disability. McLuhan (2003) anticipated the close relationship between art and media, particularly in reference to the ways that they combine to influence our senses. For McLuhan (2003) “art provides the training and perception, the tuning or updating of the senses during technological advance” (p. 208).
While the results of this study may be instructive to a broader population of people we focus on users with
disabilities as they are a group for whom the use of new media technologies are sometimes assumed to be less useful
in non-therapeutic applications. In the spirit of STS scholarship, which has incorporated and resurrected earlier
technoscience scholarship including McLuhan’s Laws of Media (Fuller, 2007, p. 2), we seek an understanding of
how new media could alter disabled users’ engagement with art-making as expression and participation, and in so
doing open the status quo, and shift the ways that we may understand each other.

**Background and influences**

This study was inspired by students who are members of the Visual Storytelling Club (VSC), an extra- curricular art
initiative for adults with moderate intellectual disabilities who are enrolled in a college program in Toronto, Canada.
The VSC meets regularly with the intention of making art, creating art for self-expression and connection, using art
for communication, and engaging with art for fun. During a VSC meeting in the fall of 2010 students were using
Adobe Photoshop on Mac desktop computers to manipulate and experiment with images that they captured in the
previous week. Some of the students have hand mobility impairments and at times, drawing and painting with a
mouse proved to be difficult.

A student with a visual impairment had to climb on to the desk and view the monitor from a distance of a few inches
with his head at a 90-degree angle in order to see the image on the screen. As the instructors wondered about an
easier way to support the artist’s engagement with drawing and painting exercises using computers, a series of events
unfolded. An article in Vanity Fair magazine about the iPod and iPad art of photographer and artist David Hockney
led to a conversation with a researcher who was doing research on tablets and autism, which lead to the design of this
research study. We began with the desire to explore how a hand-held tablet might impact on the creation of art for a
group of adults with intellectual disabilities.

We were also inspired by the work of Mullen (2000), who considers artistic self-expression as holding the potential
to foster social interaction and communication. We wanted to consider relationships among the actions undertaken to
make art, the use of tablets (i.e., tablets), and interpersonal communication. Mullen (2000) states that, “[a]rt can start
an encounter with another, and it can destabilize our terms of reference governing that encounter. To this extent it
may enhance the possibilities that will emerge from that encounter with changed beliefs and attitudes” (p. 128). We
are interested in the possibilities that emerge from making-art using tablets for adults with intellectual disabilities – a
population for whom social interaction and communication can sometimes be problematic.

**Making art for art’s sake – not as therapy**

While there are studies that examine the use of visual arts for therapeutic outcomes (Demanchick et al., 2003; Gilroy,
2006; Harlan, 1990; Malchiodi, 2003; Peppler & Warschauer, 2011), there are fewer research projects pertaining to
adults with intellectual disabilities creating art as a voice and a means of expressive communication.

Art can be a very therapeutic practice but for many disabled people, art and therapy are most often linked. An art
practice enjoyed by able-bodied people is seen as personal expression whereas the same project by disabled people
becomes therapy. Art + Disability = Therapy (K. Church, personal communication, January 15, 2013). Expressive,
creative art made by adults with intellectual disabilities is rarely observed outside of the limitations of labels and
stereotypes, or is alternatively viewed through a pervasive clinical or therapeutic paradigm as: art therapy (Huang, &
Dodder, 2003), art as treatment and repair (Sutherland, 1997) and art for occupational therapy (LaMore & Nelson,
1993), which frame disability as a deficit (Fraser, 2010), as something that is broken and can be fixed.

When art produced by adults with intellectual disabilities is viewed simply as “art” the work is often subjected to
measures or comparisons with art produced by persons of a “typical” development and age and consequently
perceived under the umbrella of “art by children” (Harlan, 1993; Kim et al., 2006; Carlson, 2009) or as Outsider Art.
Outsider Art has many definitions including: self-taught, authentic and visionary but this contentious term can also
have dismissive, negative connotations that speak to social exclusion, alienation and isolation and can be described
as art by people outside the mainstream or “other” (Rhodes, 2000; Clement, 2006; Eisenhauer, 2009; Wojcik, 2008;
Buttimer & Tierney, 2005).
Rather than looking at art through the disenfranchised lens of intellectual disability where the value of the art is considered only as incidental to the cognitive and/or physical obstacles overcome in its production (Nunez 2009; Muri 2007), this study builds on Goggin and Newell’s (2003) and later Ellis and Kent’s (2011) concept of “doing production,” where they consider features of media that facilitate and oppose the art-making process. We investigate the potential for expressive communication and creative art by adults with intellectual disabilities via media by framing study participants who engage in the process of production as “students,” “artists” or at other times as “users.”

Contrasting media in the art making process

In order to more fully interrogate the role of the tablet as a medium in the art-making process we compared the artist’s experiences on tablets (i.e., iPads) with that of more traditional paper-based media. This allows for a more detailed analysis of what may be different about the artist’s interactions on tablets versus other media. These media were selected since they share some properties (i.e., tactile or touch elements), while also offering a contrast between a more traditional, non-digital art making medium versus a relatively newer electronic format.

Again, McLuhan’s theorising on media is particularly helpful as we examine touch media – of which both paper and marker and tablets qualify as examples. McLuhan described the actual handling of an object as using the sense of touch as a sensory translator, and he conjectured that by employing the sense of touch the user was both experiencing the medium as an extension of herself, and through direct manipulation was transforming how she could understand the object in a new way (Gouzouasis & LaMonde, 2005, p. 3).

Research questions

The following research questions guided our study:

- **RQ 1:** Is the art-making process altered by the use of tablets when compared to employing more traditional art materials?
- **RQ 2:** Are there communication and social interaction consequences of using tablets for the artistic self-expression of users with intellectual disabilities? Based on the findings we hoped to apply McLuhan’s tetrad as a model that would allow us to analyze the impact of the experience for the users.

Methods

Research site

The research took place at a large Ontario college that provides a specialized 2-year certificate program for students with intellectual disabilities. The program provides students with moderate intellectual disabilities the opportunity to have a college experience. Students in this program are typically reading and writing at grade one to three levels. Staff from the program provides students with modified tests and assignments that suit their individual academic level and provide varying levels of assistance with problem solving, managing interpersonal conflict, assisting with self-advocacy, clarifying information by re-phrasing and using plain language accompanied by concrete examples.

Research participants

Each academic year, for a two-hour period, once a week for 10-weeks students are inspired to create art projects that invite and encourage visual communication and explore expressive communication. A variety of media are used including internet use to search for images; magazine images, paper, scissors and glue to create collage; pens, felt markers, pencils and paper to draw and studio lighting, digital cameras and computers with photo editing software to capture digital portraits and images.

Participation in the research study was voluntary and students were able to participate in the Visual Storytelling Club, but not take part in the research study. Students in the research study were free to stop participating at any time,
without penalty. Recruitment took place in February 2011 during the first session of the VSC, and data collection began in March 2011. Thirty-seven students were invited to participate, twenty male and seventeen female with eighteen agreeing to participate. All were English-speaking and the group represented a diverse range of ethnicities and cultures.

Students were provided with plain language documents such as the information letter and informed consent forms for all necessary activities including participation in the research, art show and consent to being photographed. All of the students were adults, 19 years of age or older at the time of the study, and had the legal right to make their own decisions. After signed copies of the informed consent forms were collected, they were handed over to the Principal Investigator, who worked out of a different educational institution and had no prior relationship to any of the participants. The Visual Storytelling Club proceeded with its usual activities with the VSC facilitators and program staff unaware of who had agreed to participate in the research and who had not. Most participants had prior experience with tablet devices and this was not an exclusion criteria as researchers were not examining media skills but instead focused on art-making processes.

Research design

Eighteen-hours of observations were documented during the course of the three-week study. The principal investigator developed a qualitative research plan to analyze the ways in which student-artists engaged with the provided materials to create self-portraits. Pre-observational data regarding the student’s names, ages, formal diagnoses, ethnicity, dominant-hand, attendance in the class and prior use of tablet devices before the study were collected from the class instructors. Researchers were trained to observe and record participant’s process by taking digital images, written notes, maps, graphs and screen captures of the participant’s artwork.

Observation notes were recorded using a protocol that included descriptions of the physical location of the students, their proximity to others in the room, any hand and body movements, communication, or adjustments to the media being used. Using 10-minute intervals, each observer would select a different student and focus on this student for the duration of the period. We paid close attention to the choice of materials selected (including applications), the pace of work, the distance in inches between the participant and the medium (using photos and reference marks on the tables), and recorded facial and behavioural cues, such as smiling, frowning, squinting, pounding of tables, etcetera. Different researchers would observe the same student in different time periods and notes were summarized, coded using MS Excel, and analyzed. By having different researchers observe the same student, and by using the photos, we increased the level of internal reliability for the study.

By using ethnographic and participant observations data were collected while artists were in a typical classroom environment. This is a non-obtrusive way to achieve the data collection goals, and is a data collection approach recommended in the field of information studies (Hartel & Thompson, 2011; Dervin, 2003). Program staff members were present to support students as necessary but were not involved in the data collection.

Finally, we conducted informal discussions with individual students and with the class as a whole. We asked them to tell us what they enjoyed and disliked about using the paper and markers, and the tablet, and invited them to share any other thoughts about the stories that they were telling using the media. These discussions were recorded through the use of a note-taker, coded by researchers, and added to the dataset.

Findings and data analysis

Two-types of activities were designed to facilitate the artist’s engagement with the different art media. For the first activity, six assorted-colour felt-markers were placed on each desk in front of the artist along with several eight and a half by eleven-inch sheets of un-ruled, white paper. Artists were instructed to draw a full body self-portrait, including the head, hands and feet. For the second self-portrait activity, a tablet was placed on the desk and the artists were again asked to draw a full body self-portrait with the choice of three applications; Artrage and Drawcast offered full colour options and ASKetchlite, a black and white only drawing program. Approximately 10-minutes were devoted to each of the activities.
Data were recorded for the following variables which give insight into art-making processes: orientation selected by the artist (landscape or portrait); dominant hand used; distance between artist’s face and the medium; use of colour; quantity of art work produced; interest and motivation; social interaction and communication; and drawing style.

**Paper and felt markers**

**Paper orientation**

A facilitator distributed the paper and, with one exception, artists re-adjusted the paper so it was vertically positioned on the desk (i.e., in portrait versus landscape orientation), see Figure 1 for an example. Once the drawing began, several people readjusted the paper to a diagonal alignment on the desk but repositioned their body so they were still drawing to a vertical position. The paper was anchored by some artists with their non-dominant hand for the entire drawing activity and was lifted to show other people in the room but only on completion of the image. Upon completion, the self-portrait drawings were held up and shared with other artists in the room.

**Dominant hand**

Prior to the research, each artist was asked to indicate which hand they used for writing and drawing and it was noted that all artists used their dominant hand to draw their self-portrait with the felt markers. Several artists used the opposite hand to hold the paper steady in place on the desk and others used their non-dominant hand to shield their work. Artists did not switch hands to draw or to hold the paper steady and some of the artists held their non-dominant hand in their lap or on top of the desk while drawing.

**Distance from eye to paper**

Every participant sat in a chair at a desk and the distance from eye to paper did not change substantially during the activity. Digital images captured during the data collection indicate that the approximate distance from eyes to paper was between twelve and sixteen inches and this distance remained the same for the entire exercise. In fact, there was very little bodily movement while drawing the felt marker and paper self-portraits.

**Use of colour**

Artists made initial colour choices from the random selection of markers that were placed on their desks by the facilitators and would ask each other for specific colours when required. All the self-portrait images were realized in two or more colours and there was no erasing, revision, re-doing, scratching out or starting over. In this way there appeared to be a commitment to the lines once they were drawn.

**Quantity of work**

Artists worked for the full ten-minute time period, producing one self-portrait image. A few artists wanted to continue drawing with felt markers and paper on a new piece of paper when the self-portrait exercise was completed, even as the tablets were being introduced.

**Interest and motivation**

Artists were very focused and engaged in the activity. There was very little body movement (moving around, turning in the chair, standing up) while drawing with the felt markers and paper. Conversation was consistent but subdued until the ten minute drawing period was over. During the drawing period, one artist looked at other drawings and copied ideas and another asked for help in spelling some words, offering to explain the inspiration for her image to the facilitator.
Social interaction and communication

All artists faced forward and remained seated and relatively still while drawing. There was very little moving, fidgeting and turning around. If another colour felt marker was required, the artists stood up to pass or retrieve from another person and returned to their seat. Some people leaned back in their chairs and held up their work to show it to others but only when the self-portrait was completed. Their bodies were fixed in position and the paper was held on the desk with the non-dominant hand. All artists were seated in a desk and most were sitting beside another person. During this activity, there was conversation between seatmates (“What are you drawing?” as well as requests for a specific colour felt marker). There was a tremendous amount of sharing of markers between artists.

Self-portrait drawing style

Every artist revealed a unique drawing style with certain similarities. All eighteen artists completed one self-portrait drawing in the 10-minute time period. One image was horizontally orientated and seventeen images were vertically orientated. Each drawing represented a full body figure including a large, round head with facial features, arms and legs and all used two or more colours. In eleven of the self-portrait drawings, the figure was centered on the page and in seven of the images; the figure was to the left of centre. Two images featured figures on a slight fifteen percent diagonal—one leaning to the left and one leaning to the right. In three images, the figure is standing on a line representing the ground and fifteen images feature a floating figure. Most of the figures filled at least two-thirds of the eight and a half by eleven-inch page. Eight self-portraits are embellished with designs such as hearts, flowers and colourful shapes and four images incorporate the participant’s name as part of the drawing. It was noted that the artists did not use the felt marker to colour in the skin tone in any of the drawings.

![Figure 1. Paper and marker art](image)

Tablet

Paper orientation

The tablet was often in motion for many of the artists. It was spun around, tapped gently to a slight spin, pivoted back and forth and used both horizontally and vertically, although most of the images were realized and saved in a vertical orientation. The tablet was moved from desk to lap and one artist held the device approximately two-thirds of an inch above the desk. Another held the tablet on an angle, leaning it against his stomach and the desk. Some of the artists struggled with orientation before settling. Many artists held the tablet up to show others their work as it was in progress.
Dominant hand

For many students there was neither a dominant hand nor a dominant drawing finger. Both hands were used to select apps, choose colours, brush sizes and styles, to type, delete and erase details and to zoom in and to zoom out. At times, the dominant index finger was used to draw but data and digital image capture also suggested that artists used their smallest finger, thumb and the side of the palm of the hand as well as fingers on the non-dominant hand, see Figure 2 for an example. One artist used a very gentle motion to draw, barely touching the screen and another used a repetitive tapping motion. The tablet was not always anchored and held in place. There were examples of artists resting their unused hand in their lap or on the desk and two incidences of the unused hand playing with their hair. Another toggled the tablet with small touches on the corner of the device. One artist constantly touched her right ear when she was not drawing with her right hand. Some artists shielded the tablet by using the non-drawing hand or their bodies to block the image, especially when they were focused on their work.

Distance from eye to tablet

The distance from the eye to the device varied from four to five inches from the screen to twelve or more inches. One artist held the tablet and brought it very close to his eyes and then put the device on the desk and moved his body so his eyes were just as close. Artists freely moved back and forth, closer and farther to the screen of the tablet.

Use of colour

The artists used one of three programs to draw their self-portraits. Seven images were drawn in black and white only using the ASKetchlite app. Eleven artists used full colour for their self-portraits. There were five artists who erased, revised and redrew their images and two artists who attempted to recreate the self-portrait they had previously drawn on paper. Some artists appeared to be indecisive and had a difficult time choosing from the many available colours and brush styles and sizes.

Quantity of work

Fifty-five self-portrait images were created by eighteen artists in the 10-minute time period. Some artists drew three or four images each in a ten-minute period. One artist cycled through the three apps very quickly and another completed five drawings, each one taking approximately two-minutes to complete.

Interest and motivation

Generally artists appeared to be absorbed in drawing but some were easily distracted, turning around to look at other’s work, to talk to or to help others. Most artists returned to the task after a brief diversion. Artists worked quickly and immediately and freely made revisions, deletions and changes.

Social interaction and communication

Most artists remained seated while drawing but often turned around in their chair to talk to others and held up the tablet to show and share their work with others. Some artists stretched out over the desks and put their heads down to draw and used the non-dominant hand to shield their work. Other artists were loudly chatting and laughing. They appeared to be absorbed in their work focusing for periods of time between one and three minutes, but excited to share their images with others. Most were able to return to the task. Others were quiet and hid their work from others. Emotions were visibly expressed via frowns, smiles, laughter, and other facial expressions. Frustration with the device led to asking for help from the facilitator, staff and from other students. Some people said they were bored and others said they were very tired, putting their heads down on the desk. One participant was very joyful and was “dancing” in her chair.
Self-portrait drawing style

Artists completed between one and five self-portrait drawings in the ten-minute period, moving between the three applications. Four images were drawn to a horizontal orientation and fifty-one were vertically orientated. Most drawings represented a full body figure including a large, round head with facial features, arms and legs but several artists drew only a round head with facial features made up of abstract colours and/or shapes. The two colour apps had the option to change the colour of the background to black or to various textures and colours. Eleven self-portraits were made on a black background and two were drawn on a shiny silver textured background. Thirteen images were drawn using black only on a white background. In most drawings, the figure was centered on the background and appeared to be floating. The feet are suspended in the air and none of the images feature a line indicating the ground or floor. The figures do not fill the screen and some are very tiny as the artist zoomed in to draw. Only one participant used colour to make a skin tone. The images vary in detail and one image only was embellished with hearts and flowers. Four images out of fifty-five incorporated the name of the artist as part of the drawing.

Figure 2. Tablet art by an artist with right-hand dominance

Discussion

The project of drawing self-portraits offered a genuine non-therapeutic art making experience, which was an alternative to language as a way of communication and inspired creativity and connectedness. The activity encouraged the artists to use a selection process in choosing individual colour and drawing technique and design, which fostered critical thinking and active participation in portraying self. The self-portraits empowered and gave a valid voice to the artists who may not perceive themselves as intellectually disabled, but as artists. This sense of self as a creator of art was further validated by displaying their art in a show open to the college community as well as the community at large, including family and friends.

Comparing media

In response to the first research question, is the art-making process altered by the use of tablets when compared to employing more traditional art materials, we found that the medium did change the ways that the artist approached the projects. With felt markers and paper, the page orientation was conventionally placed in “portrait” style. The artists used their dominant-hand to draw and the non-dominant hand to hold the paper flat on the desk. Body positions were fixed and relatively motion-less for the duration of the drawing activities, and the distance from face to paper – averaging about twelve inches - did not change. Each artist used the complete ten-minute period to complete one drawing only. Artwork was shared and viewed by others by holding up the drawings, but only upon completion. The permanence of the felt markers on the paper seemed to create a strong commitment to the drawings. There were similarities in the final felt marker and paper self-portrait images. Most images consisted of a full body, with large, round head and facial features. The figure was regularly centered in the middle of the page or on the screen and floating above the ground. In all but one image, there is no attention to skin colour.
In contrast, the tablet self-portrait images were less detailed and more unplanned and abstract than the images drawn with marker and paper. The artists worked quickly, drawing fifty-five images in a ten-minute period. Artists freely made changes, revisions and deleted work as they experimented with the three applications. The tablet was held in a number of ways, rarely anchored on the desk and held much closer to the face, as close as four inches.

Regarding the second research question, are there communication and social interaction consequences of using tablets for the artistic self-expression of users with intellectual disabilities, we found that when using the tablet the artists were more social with each other and turned to share their work in progress or often looked to the desk behind them. The project created an environment that fostered partnership and teamwork, as lively discussion and sharing of work engaged the artists. There was a great deal of experimentation by drawing with the dominant and non-dominant hand as well as by drawing with all the fingers and the palm of the hand. The quick and immediate results expanded and enhanced creative expression, collaboration and offered inspiration. Although there was some frustration with choosing from the vast quantity of colours and impatience when the result of the function of an application was unexpected, the choice of colour, texture, background, and brush size influenced the artist to see and to think in new ways, beyond the traditional marker and paper.

McLuhan and McLuhan (1988) theorized that the user, in this case the artist, was transformed by the media used. The emerging digital tablet technology facilitated social interaction in a creative, fun and innovative self-portrait art activity, with the opportunity to express and explore creative communication. Involvement in this art activity encouraged the students to view themselves as artists. The benefits to the students included enriched communication skills, opportunities for collaboration, confidence leading to increased independence, enhanced creativity, access to new and emerging technology among their age group and increased the possibility for connectedness to the larger community.

Laws of media

The results suggest that the forms of the media used in creating the self-portraits were consequential for the actions and processes that the artist engaged in when making art. McLuhan maintained that human communication media are extensions of one or more of the senses (McLuhan & McLuhan, 1988). This was a recurring theme in Marshall McLuhan’s (1994) work in media theory, where he posited that the medium or technology itself had the potential to reorganize processes via sensory engagement. This potential to reorganize is directly related to the sense ratio enlisted in the engagement of the user with the technology; this is what McLuhan termed the “sense ratio,” defined as the number of senses actively involved in the perceptual process (Gouzouasis & LaMonde, 2005, p. 7). On reflection of the data we note that the media used in this study appeared to enlist the senses of the artists in different ways. For example, while both the paper and marker media and the tablet engaged the visual perception, and tactile senses of the artists, the tablet was able to also enlist audio perception (through beeps and other noises when using some drawing tools), and offered a richer experience of tactile perception due to the direct manipulation of the drawing objects on the surface of the device. The tablet was also heavier, cooler in temperature, and offered three different applications with a greatly extended set off colours, visual textures, and virtual application tools, such as brushes, charcoal, pencils, spatulas, and so on. Therefore, the tablet offered a smaller sense ratio that afforded the artist a deeper opportunity for sensory immersion, or reorganisation, within the art-making process.

Tetrads

The tetrad is an analytical model created by McLuhan to facilitate the translation of user experiences of media. A tetrad is comprised of four lenses, representing simultaneous processes that are engaged when a user manipulates a medium. The construction of a tetrad is predicated on four questions: (a) what does the medium enhance; (b) what does it reverse; (c) what does it retrieve from the past?; and, (d) what does it make obsolete (McLuhan & McLuhan, 1988, p. 129-130)? The answers to these questions result in the description of four media effects, namely enhancement, reversal, retrieval, and obsolescence. These four effects are not isolated but are tightly interrelated and co-constitute each other.

Gouzouasis and LaMonde (2005) used McLuhan’s concept of tetrads to analyze arts-based media in the form of sonatas. Likewise, we found McLuhan’s concept of the tetrad to be particularly applicable to our sociotechnical
investigation of the visual storytelling context since tetrads include the analysis of sensory processes, such as those used in making art, with those of social interaction through communication. Based on our study results we applied McLuhan’s concept of the tetrad as a lens for analysing arts-based media and specifically the effect of the tablet on the group of artists participating in this project.

Using the study data we constructed two tetrads – one for the paper and marker media, and another for the tablet as the media in the center of the tetrad. In Laws of Media McLuhan and McLuhan (1988) constructed a tetrad analysing the written word as a medium. This offered a good starting point for the development of the tetrad for paper and marker media in our study. For the written word McLuhan and McLuhan (1988) found that private authorship and the ego are enhanced, collective/historical sense is reversed, elitism and class distinctions are retrieved, and dialects and slang are obsolesced (p. 154-155). Using paper and marker as the media under analysis we see some parallels with the written word as they both enlist a similar set of senses. For our art-making using paper and marker tetrad we find that artistic-ego is enhanced, the “artist as a professional” notion is reversed, visual storytelling is retrieved, and linear narrative is obsolesced.

From the data we find that the use of the tablet by the artists enhanced processes of experimentation, reversed or lowered the artist’s sense of commitment to the iPad artwork compared to the his/her work with marker and paper, retrieved processes of peer-learning among adults with intellectual disabilities formerly witnessed in their childhood, and made obsolete the audience’s typical preoccupation with focusing on the disability of the artist over a focus on the art itself - see Figure 3 for the tablet tetrad.

![Figure 3. Tablet tetrad](image)

Our goal in this project was to conduct a comparative media study of adults with intellectual disabilities who used tablet devices for visual storytelling. We chose to examine the interactions between disabled users and media with a particular interest in exploring the role of sensory perception in their artistic explorations. Some of the boundaries were transparent – could people with intellectual disabilities use new media (did they have the skills or expertise); is the output of their engagement with media for visual storytelling therapy or art; and would traditional art-making media be easier to use for this population? Some of the boundaries were emergent – what did the artists gain from the interaction with the media; how did the artists and the devices impact the art-making process; and does the artist’s perception of disability shift (and does ours)?

The results demonstrated that art-making processes were altered by the use of tablets when compared to employing more traditional art materials. Of the examples described earlier the contrast between the strong commitment and attention to detail when using the paper and marker media versus the more experimental and rapid production on the tablets is thought-provoking. At the time of the study the tablet was still a relatively new and uncommon device used at the college. Only one of the artists in the study indicated that he had used a tablet and many students remarked that they were excited that they would have the chance to use one. Intuition, therefore, suggest that the novelty of the tablet device and lower levels of experience in making art with it may be an explanation for the shorter spells of time on individual pieces.

Yet is this a literacy issue or a sensory processing one? An alternative explanation could be that the media with the lower sense ratio – the tablet – engendered a more satisfactory sensory experience in a shorter space of time leading to a higher volume of work produced. Or perhaps this is coupled with expectations gleaned from experiences with
other new media – such as digital photography - that the art on the tablets could be made quickly, saved, and shared more readily. Or perhaps the seemingly vast number of choices and affordances of the tablets are actually not viewed that way at all – and are experienced as deficits when compared to using a marker on paper.

We observed that the tablet appeared to facilitate and foster increased communication and social interaction among our artists with intellectual disabilities, when compared to activities involving more traditional materials. Artists were quick to share their work-in-progress as well as the completed artwork with others. Art created with more traditional art supplies was produced in a more solitary manner and less readily shared among artists. Is this another instance of an intuitive flip where often-touted fears of isolation and anti-social behaviours have tended to be associated with new media but may be over-stated?

Conclusion

STS scholarship including the application of technoscience analytical lenses like the tetrad are helpful as we investigate topics of disability, ability, and the role that media play in user’s engagement with content-creation. We hope that future studies are conducted that might compare the influence of different types of media on the communicative experiences of disabled people. We also encourage contestation and further development of the tetrads that we have constructed so that the media effects witnessed in this study, and in others, can contribute to a growing field of knowledge.

As a result of this research study, the certificate program for students with intellectual disabilities has purchased 30 tablets for use in the various courses offered, and they are currently a regular feature in the VSC. The potential uses for tablets as both an educational and creative tool are being explored. As tablets are increasingly integrated into a variety of settings we offer this application of the tetrad as an early step, and anticipate future research on how we may further analyze and interpret the impact of these technologies for people with a range of intellectual abilities.

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References


Towards Situation Driven Mobile Tutoring System for Learning Languages and Communication Skills: Application to Users with Specific Needs

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ABSTRACT

Current advances in portable devices and wireless technologies had drastically impacted mobile and pervasive computing development and use. Nowadays, mobile and or pervasive applications, are increasingly being used to support users’ everyday activities. These apps either distributed or standalone are characterized by the variability of the surrounding environment, the constrained devices’ characteristics and specifically the context they are used in. Building mobile apps that support the user while spanning different contexts and experiencing different situations, needs therefore to use relevant mechanisms dealing with mobility, context awareness, and adaptability. In this paper, we propose a new adaptable and re-configurable mobile Intelligent Tutoring System (ITS) architecture for acquiring relevant communication skills in different situations taking into account persons with specific needs. Adaptability and context awareness are addressed by combining and porting OSGi features and Semantic Web technologies on top of an Android platform.

Keywords

People with specific needs, Mobile ITSs, Semantic Web Technology, OSGi middleware, Dynamic adaptability

Introduction

Advances in mobile devices and related technologies are increasingly allowing the emergence of new applications. However, the very changing characteristics of mobile devices and their surrounding environment may lead to undesired and unpredictable situations preventing the user to use required services at a given time. Moreover, even though those characteristics may still unchanged, the user’s mobility or her disabilities implies new or different situations and activities requiring new supporting services or adaptation of existing ones (Conde et al., 2009). For instance, during a common day life, the user may experience activities within which she is required to communicate and use domain specific expressions. She may be required to speak in a different language than her native or also experience strong communication problems and can’t be aware of her surrounding environment (Massaro, 2004).

Acquiring new communication skills in formal or informal way by making use of technology have been addressed by researches since a long time (Shute & Zapata-Rivera, 2012). Indeed many researches in e-learning had established pedagogical methods, standards, tools and platforms in order to support learners and to provide them with learning as well as assessment activities for learning languages or social skills (Grawemeyer, Johnson, Brosnan, Ashwin, & Benton, 2012).

Some have addressed communication aspects intended to people with disabilities such as autism or impaired hearing (Jaballah & Jemni, 2013; El-Sattar, 2008; Venkatesh, Greenhill, Phung, Adams, & Duong, 2012). While others have focused on reviews to establish the effectiveness of the use of computer to educating people with disabilities (Askari et al., 2015; Sansosti, Doolan, Remaklus, Krupko, & Sansosti, 2014; Sanchez, Bartel, Brown, & DeRosier, 2014).

New challenging learning scenarios taking into account the learner’s context has been also provided in e-learning settings and many attempts are being taken in the context of mobile learning (Boticario & Santos, 2007; Fragale, 2014; Judy & Krishnakumar, 2012).

Moreover, intelligent adaptability aspects have been already successfully integrated in ITSs which are considered as a particular category of one-on-one e-learning systems. For instance, ITSs main purposes are to simulate the real teacher’s behavior and adapt learning processes and content to one’s learners specific needs (Murray, 1999). Unfortunately, this kind of adaptation is always defined at design time. Additionally, even though there are some works that have tackled mobility issues for ITSs (Badaracco, Liu, & Martinez, 2013), those ITSs’ architectures have not addressed modularity or dynamic adaptability to take account new user’s mobile devices, physical contexts and
new emerging needs especially those related to the appropriate use of a language within a specific context (Mahmoud, Belal & Helmy, 2014).

In order to overcome those drawbacks, relevant mechanisms dealing with context awareness, mobility, adaptability as well as adaptation of mobile apps are strongly required.

This paper, aims to provide an adaptable and re-configurable mobile ITS for supporting learning approaches addressed specifically to learning languages and communication skills for people with disabilities. In this ITS, mobility, context awareness and adaptability are addressed by combining and porting OSGi features and Semantic Web technologies on top of an Android platform.

The main contributions of the present paper are (1) the learning approach adopted to take advantages of the user’s context (mobility and specific needs) and the ITS provided (2) the flexible ITS’s architecture and its modular, lightweight and fine grained components (3) the mechanism provided for handling the user’s context and the model on which it is based and (4) the semantic and ontological descriptions of the user’s mobile context, the learning approach as well as the components and services provided by the ITS. These descriptions make it possible to run reasoning and inference rules on them. They enable, therefore, more efficient mobility and context awareness issues.

The rest of the paper is structured as follows:

In the “Research methodology” section, the research methodology adopted is presented.

In the “Learning/ supporting approach and the ITS’s specific behavior” section, the provided learning approach and the ITS’s functionalities are described.

The section “Underlying technologies for building the ITS app” focuses on the set of technologies on which the ITS will be based. Context awareness features for the Android mobile platform are described. This section ends by explaining the mechanism provided to tackle adaptability and context awareness.

In the “Semantic descriptions needed by the ITS app” section, semantics, ontological descriptions and reasoning applied to the OSGi middleware and the android platform are presented.

In the “Implementation and validation” section, a concrete architecture of the mobile ITS app and its components is presented and the manner it is used to allow adaptability and mobile context awareness is explained. As a proof of concept, in “The mobile ITS app context aware architecture” section, an implementation and a validation based on scenarios that illustrate the provided solution is presented.

Finally, in the “Conclusion and future work” section, some conclusions are drawn and future works are outlined.

**Research methodology**

Firstly, the main research question addressed by the present paper deals with the kind of ITS and adaptation approach to provide in order to support relevantly users and their changing needs as well as a large diversity of users with different disabilities.

To answer this question a list of criteria, characteristics and requirements have to be established. Different sources have been used to establish that list namely literature review about users’ specific needs and existing ITSs provided to support those users for acquiring skills as well as scenarios’ elaboration and analysis to highlight users’ requirements.

A proposed solution and a corresponding prototype have been provided.

Evaluation of the proposal have been realized by simulating presented scenarios and comparing the required system’s behavior to the effective behavior of the system. The results are analyzed and conclusions are drawn.
Literature review

Learning systems for learning/supporting persons with disabilities

During these last decades, several Intelligent Learning Systems (i.e., ITS or iLMS) have been realized to help in acquiring foreign languages and/or communication skills as VocaTest (Kazi, 2005), TenseITS (Cui & Bull, 2005), CAMLES (Nguyen, Pham, & Ho, 2010), LingoSnacks (Erradi, Nahia, Almerekhi & Al-kailani, 2012).

Most of these learning systems focus on modeling tutor activities via artificial intelligence techniques to adapt content delivery to the student, according to his/her particular characteristics (learning style, behavior, performance, and whether the student has a disability or not) (Cuesta, Ramos & Pavlich-Mariscal, 2012). Adaptation could also be based on the user’s location, concentration, time and interruption/distraction (Cui & Bull, 2005), or more generally on the user’s context (Nguyen et al., 2010; Uosaki, Ogata, Sugimoto, Hou, & Li, 2012).

More specific ITSs have addressed users presenting the autism spectrum disorders (ASD) and tackled specifically the teaching learning strategy (Coleman-Martin, Heller, Cihak & Irvine, 2005; Sarma & Ravindran, 2007; Drigas, Kouremenos, & Vrettaros, 2008; Judy & Krishnakumar, 2012; Vullamparthi, Khargharia, Bindhumadhava, & Babu, 2011). Others have provided authoring tools to help and advice non-experts as parents and caregivers to create instructional modules and interactive social scenarios (Boujarwah, Riedl, Abowd, & Arriaga, 2011; Conde et al., 2009).

Following works have however, addressed new communication features with the system.

For instance, Baldi offered a computer-animated tutor for teaching vocabulary and grammar to children with autism and those with hearing problems (Massaro, 2004). The TUTOR project (García et al., 2006) have proposed an ITS that integrates multimodal tools and human emotional feeling analysis to improve its usefulness. Study in (Sitdhisanguan, Chottikakamthorn, Dechaboon & Out, 2008) had suggested a Tangible User Interface (TUI) based tutoring system. ActiveMath a mathematic ITS have provided a man’s eye tracker to trace child’s attention and reading time (Melis & Siekmann, 2004). Authors in (Ritchings, Khadragi & Saeb, 2012) have developed a computer-based system for Sign Language tutoring using a data glove and a software application. El Ghoul and Jenni (2009) have proposed a Web based environment to help deaf people learning sign language where written texts are automatically interpreted in visual-gesture spatial language using avatars which was later enhanced with a new animation approach that ensures real-time generation of the virtual character postures (Yahia, & Jenni, 2013). McCrickard, Abel, Scarpa, Wang and Niu (2015) have proposed a methodology to help future designers to propose relevant interface to people with ASD.

Finally, authors in (Conde et al., 2009; Irigoyen et al., 2010) have proposed the LAGUNTXO system which provides an assisting tool based on an intelligent structure for tutoring system’s configuration and allowing any stakeholder (tutors, caregivers and relatives) to configure the ITS in two dimensions considering the characteristics of the operational task and the diversity of the disabilities. For that aim, an automaton-based mechanism has been developed to technologically adapt the large amount of possibilities related to the interaction between people with disabilities, the task that is going to be made autonomously by these people, and the system elements.

Context awareness and mobility in ITSs

Recently a few research works have addressed mobility and its challenges when it is applied to ITS or iLMS (Badaracco et al., 2013). The main focus of these works are how to deal with content, data storage and Human Communication Interfaces (HCI) within devices with constrained characteristics and features (Badaracco et al., 2013; Brown, Lee, Salvucci & Aleven, 2008; Boticario & Santos, 2007).

Two categories of works have tackled differently those problems. The first one makes content authoring (Stankov, Rosić, Žitko, & Grubišić, 2008) and HCI customization outside the mobile device in a static manner (Brown et al., 2008), (Zatarain, Barrón-Estrada, Sandoval-Sánchez, & Reyes-García, 2008).
The second category uses client/server architectures mainly Web oriented and so data processing, storage, reasoning, HCI adaptation or customization is done server side (Kazi, 2005). Synchronization techniques are also used for updating the client and its constrained data base. We notice therefore that adaptability implemented in these works concern only learning content, pedagogical learning paths and HCI (Ghadirli & Rastgarpour, 2013).

However, it is worth to stress that a software architecture and its flexibility for (re)-configuration, is a strong condition for context awareness and mobility. A survey and comparison between ITSs architectures have been done in (Mastour & Khemaja, 2013). The survey have considered Desktop or standalone ITSs, Web Oriented Architectures (WOA) (De Bra & Calvi, 1998), Services Oriented Architectures (SOA) (Dolog & Nejdl, 2007), multi-agents based architectures, (Lavendelis & Grundspenksins, 2008), Semantic Web based architectures (Vesin, Klašnja-Milićević, Ivanović & Budimac, 2011), (Merino & Kloos, 2008) and finally hybrid solutions combining more than one architecture. The comparison have considered flexibility adaptability and auto reconfiguration, as well as elements concerned with adaptability as content, interface and granularity or weight of services and components.

As a conclusion at the best of our knowledge, none of the existent research works have addressed functionalities or re-configuration of Mobile Intelligent Learning Systems at runtime, specifically by making use of ontologies and semantic reasoning in the client side to provide context aware services. Moreover, described ITSs address specific learning strategies and content which are predefined at design time and may not change at runtime. Except the LAGUNTXO system (Conde et al., 2009) that applies some kind of re-configuration, these systems are not able to respond rapidly to change and do not offer the possibility of applying sound and intelligent re-configuration based on human expertise and heuristics.

**Scenario description and analysis**

This section provides a motivating scenario where mobility constraints and aspects are changing and so do the learner’s needs and context. The scenario analysis will highlights some challenging issues and guides the manner to address them.

**Scenario description**

Sabine is a teen girl presenting several communication disabilities. Her parents always try to engage her within activities allowing her to acquire communication skills. They also offered her a lightweight version of an ITS which is embedded and deployed on her mobile device. This ITS addresses specifically a subset of English language for specific use at home. After several weeks of experience, Sabine had successfully worked on all the provided activities. However, she still requires additional activities to enhance her communicative skills. Her school teacher proposes her a new ITS version with much more activities and vocabulary including location based ones. Unfortunately, due to hardware constraints, this new version could not run on the Sabine’s mobile device. Moreover, although that Sabine were progressing successfully to learn, she is still facing several communication difficulties due to her ASD disability especially when she needs to deal with specific domains.

**Scenario analysis**

Even though, the initial version of the ITS have at the first time satisfied Sabine’s needs, these latter have changed. The idea is therefore to allow Sabine and the other learners with various needs to benefit at the same time from different services provided by a given ITS’s configuration and its upgraded versions, to share services between each other and equally to benefit from services available in the surrounding environment.

Moreover, a part of the previous technical requirements, some pedagogical considerations could also be taken into account. For instance, if Sabine is moving and do not have enough time to take long assessment tasks or when she needs to learn other specific expressions and terminology the ITS’s should provide the best fitted service.

The intended scenarios are therefore that devices speak to each others, with buildings, campus facilities, etc. take account the user’s context and so provide her with the best experience.
As a conclusion, following requirements are highlighted (1) A new ITS’s architecture is needed. This architecture should be flexible, adaptable, re-configurable and also lightweight to fit into mobile constrained devices. Moreover ITSs components should be fine grained to allow rich and efficient adaptability and re-usability. (2) A mechanism that facilitates to handle the mobile context and allows users to acquire or exchange services at runtime. It should also allow fitted services provision to learners as well to tutors taking account their mobile contexts (preferences, strategies, disabilities etc.). (3) A unified description of the context, the context awareness facilities allowed by the mobile device as well as the ITS’s services and content.

The learning/ supporting approach and the ITS’s specific behavior

The learning approach proposed deals with two kinds of scenarios; formal and informal. In formal scenarios, the learner is provided with activities allowing her to improve and acquire relevant reading, writing, speaking, listening and understanding skills. Activities are classified as illustrated in Figure 1 where each kind of skill is addressed by learning as well as assessment activities. Relevant resources and content are also provided.

![Figure 1. Taxonomy of activities](image)

To carry out successfully these activities the ITS provides relevant pedagogical strategies. An example of such a strategy is illustrated in Figure 2 where the learner receives hints and recommendations concerning writing activities. For instance, the learner is assisted to use and vary the relevant vocabulary, to avoid redundancy and also to use the correct voice either passive or active.

Besides in informal scenarios, communication skills (i.e., speaking, listening and understanding skills) are mostly addressed. Moreover, the learner is assisted in a situation driven manner. Indeed, accordingly to the learner’s location, the person or group of person with whom she will engage a conversation, the topic and the domain of the conversation, relevant vocabulary, explanations and useful linguistic expressions are displayed to the learner and allow her to train herself in such settings. More specifically, the system considers the person’s profile and her disabilities, to adapt the learning activities and content. For that aim the ITS (i.e., the learner model) diagnoses and builds progressively the learner profile by making use of the IMS ACCESS LIP standard (IMS, 2003), which will extend the user’s context illustrated in Figure 3.

For instance, people having ASD present disabilities that vary from one person to another. Signs such as hearing loss, verbal or non verbal communication skills, visual impairment, etc. constitute input information given to the system. This information allows the system to be aware of the kind of disability. Additional specific services are added compared to those used with common learners. These services concern specifically, the interaction mode provided by the system which is mainly implemented by the mobile ITS’s interface model.
Underlying technologies for building the ITS app

Three kinds of requirements have been highlighted in previous sections. To give answers to requirement (1), middleware solutions allowing software applications auto-configuration are the most relevant. For that aim, a ported OSGi middleware on Android platform is chosen. To handle context (requirement (2)), the solution attempts to take advantages of both OSGi and Android platforms for capturing context and extracting information about it, in a loosely coupled way. For that aim and also to answer to requirement (3), more semantics are needed namely for firstly knowledge representation, requesting and reasoning features, and secondly for automatic and dynamic discovery, composition and execution of OSGi services. A thorough and unified description for terminology related to OSGi, Android, Learning, adaptability and context awareness is therefore needed.

This unified description requires to be machine comprehensive. Therefore a semantic and ontological description of the overall mobile environment as well as accurate and efficient reasoning functionalities to enable this context awareness should be provided.

Details of this proposal are given in the following sub-sections and in the “Semantic descriptions needed by the ITS app” section, as well as in the “Implementation and validation” section.

OSGi terminology and models

The OSGi technology provides specifications for supporting dynamic services deployment, (re)-configuration and maintenance of software architectures based on components. It defines a standardized component oriented computing environment (i.e., a component model and a run time framework) for Java applications development and execution that simplifies configuration process and allows multiple java based components to efficiently cooperate in a single Java Virtual Machine (JVM).

The Table 1, summarizes main OSGi concepts and their definitions while the Table 2, main services provided by an OSGi Framework are presented.
<table>
<thead>
<tr>
<th>Concept</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bundle</td>
<td>A modular unit of packaging and deployment, composed of Java classes and other resources</td>
</tr>
<tr>
<td>Manifest</td>
<td>Describes the content of the JAR file and provides information about the bundle’s dependencies and its Activator class</td>
</tr>
<tr>
<td>Service</td>
<td>Is implemented by a Java class. It is accessible through at least one Interface</td>
</tr>
<tr>
<td>Service’s properties</td>
<td>Allows a service to be dynamically advertised and searched, using the framework’s services</td>
</tr>
<tr>
<td>Interface</td>
<td>A Java Interface describing methods to be implemented by a service</td>
</tr>
<tr>
<td>Package</td>
<td>Java packages exported or imported by a bundle</td>
</tr>
<tr>
<td>Bundle activator</td>
<td>Implements the start/stop of a bundle</td>
</tr>
<tr>
<td>Service registry</td>
<td>Used for managing services and their properties</td>
</tr>
<tr>
<td>Bundle’s context</td>
<td>Specifies the current context of a bundle</td>
</tr>
<tr>
<td>Event</td>
<td>Triggered when a service is registered/unregistered</td>
</tr>
<tr>
<td>Bundle’s dependencies</td>
<td>The resources needed for the bundle to run correctly</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Service</th>
<th>Role</th>
</tr>
</thead>
<tbody>
<tr>
<td>Installation</td>
<td>Implements the process of loading the JAR file corresponding to the bundle into the framework.</td>
</tr>
<tr>
<td>Resolution</td>
<td>Implements the binding process, in which each package declared as imported is wired to an exported package of a resolved bundle.</td>
</tr>
<tr>
<td>Starting/Stopping</td>
<td>For starting/stop respectively inactivated/activated bundles</td>
</tr>
<tr>
<td>Updating</td>
<td>A Bundle is modified to produce a new version</td>
</tr>
<tr>
<td>Class loader</td>
<td>A specific class corresponding to a resolved bundle allowing it to be activated</td>
</tr>
<tr>
<td>Register/Unregister</td>
<td>Applies on services</td>
</tr>
<tr>
<td>Listener</td>
<td>Observes events</td>
</tr>
<tr>
<td>Service tracker</td>
<td>Observes events on bundles services</td>
</tr>
</tbody>
</table>

It is worth noting that the OSGi service architecture is dynamic, i.e., services may appear or disappear at any time especially for the case of mobile platforms or shared registries.

It provides also a flexible deployment API for controlling components lifecycle, as well as a cooperative model where applications can dynamically discover and use services provided by other applications running inside the same OSGi platform.

Thanks to its bundle packaging, applications could be much fine grained than applications for other Java platforms. For instance, new functionalities provided by new downloaded bundles, could be installed, started, stopped, updated while useless (no more used) bundles could be uninstalled without restarting the OSGi framework.

However, even though the OSGi specification offers a high level dynamicity, bundles and their services descriptions remain syntactic and unlike in Semantic Web services Frameworks (Barros et al., 2011), the OSGi services discovery relies on syntactic properties matching.

**Android features and mobile context awareness**

The availability of sensors is one features Android devices have that makes them different from computers. Thanks to sensors’ capabilities, which could also be enriched by other user’s inputs as her agenda or other kinds of sensors, persons engaged in a conversation and the topic of the conversation, the user’s context could be captured. Context analysis allows thereafter the system to react in a relevant manner especially by supporting the learner to acquire new skills.
Since most of sensing capabilities required in the context of this work are derived from the available hardware on the Android device, and thanks to the abstraction provided by the Android platform and APIs for invoking accurately the services provided by these sensors, a context model is established and corresponding mechanism is provided.

The Figure 3 illustrates this abstraction and makes the basic concepts of the user’s context and context awareness dealt with in “Semantic descriptions needed by the ITS app.”

**Proposed configuration and adaptation mechanism**

The mobile ITS interacts with an external environment which is considered as the user’s context including the user, other people present in the environment, etc.

As defined in the literature, ITSs model is mainly composed of four components (Buche, 2005). Compliant to that model, each module is considered as an assembly of components designed to fulfill intended functions by the provision of a set of services.

The aim of (re)-configuration or adaptation is to render needed components available accordingly to the user’s current context. Observation and context awareness is performed by a specific manager that is attached to each ITS module component and decides whether the configuration or reconfiguration is needed. This manager has the responsibility to implement the configuration and the adaptation policies (as for example Selecting relevant components to be used, Elaborating the components activation plan; Adding removing or replacing a component).

Moreover, each OSGi bundle in the ITS provides a kind of interceptor or listener (sensor) placed on parameters or monitored variables that could be changed when a context element changes and so a specific handler (actuator) is activated to respond to those changes. Thus the ITS’s context manager, will interact with each module manager.

Since the ITS is OSGi based and ported on the android platform, the ITS’s context manager is implemented as an android service running as a background task and which is bound to the main ITS activity as illustrated by the Figure 6. It should have reasoning capabilities to reason about context and decide which module manager it should notify and on which context element it operates changes.
Managed bundles or components subscribe to context elements they are concerned with and so when the specific context element changes, the context manager notifies the module manager which in turn notifies the managed bundle subscribed to the context element if it is available otherwise the module manager decides for applying the adaptation policy which could apply on the structure of the module or notifies managers of other modules.

**Semantic descriptions needed by the ITS app**

**Semantic description of OSGi**

In order to make the Android ported OSGi based middleware semantically richer; it has been fully based on ontologies in a manner inspired from Semantic Web Services approaches (Domingue, Cabral, Hakimpour, Sell, & Motta, 2004; McIlraith, Son & Zeng, 2001). Main aims are to provide more machine-understandable bundles/services descriptions. This could enable a more dynamic usage of OSGi services as automatic discovery, selection, composition, invocation and monitoring based on sound meaning of their capabilities.

Semantic descriptions are provided on top of the OSGi bundles registry to semantically describe bundles and services capabilities resulting therefore on an OSGi Bundles/services ontology (Figure 4).

In addition three other kinds of ontologies are equally used. Those ontologies are (1) The Context ontology for reasoning on context. (2) The Goals ontology for expressing users’ objectives independently from provided services as illustrated in Figure 4. Goals instances are derived namely from the context ontology. And finally (3) The Domain ontologies, for knowledge representation and data exchange between the systems components.

![Figure 4. OSGi bundles/services ontology](image)

**Semantic description of context**

Figure 5 illustrates a more complete view to context elements provided in Figure 3. The aim of the context ontology is to describe contextual entities related to the user, her profile accordingly to the IMS ACCESS LIP standard, her devices, location, the learning scenario, the current activity, the surrounding environment, social groups, people, conversation, topic, etc. The main aspect of this ontology is that it allows to infer new Goals from the actual context and conversely an achieved Goal could act on that context and let it evolve over time.
The domain ontologies

The set of domain ontologies comprises all the ontologies needed by the ITS as the pedagogical ontology expressing pedagogical strategies, and the taught domain ontologies. These ontologies are semantically related to the context ontology, and the goals ontology. In the context of the present work, the taught domain is formed by a set of domain specific ontologies representing the specific vocabulary and linguistic expressions of that domain and which is intended specifically for autistic people needs. Whenever, the user is faced to a certain situation especially in informal settings, the corresponding ontology is loaded allowing the user to acquire new expressions and vocabulary.

The mobile ITS app context aware architecture

The mobile app architecture proposed, provides two categories of Android components (Figure 6); Android activities and Android services.

Android activities are dedicated to manage the user’s interface, they implement therefore only components for visualizing information or capturing the user’s inputs.

Main heavy processing are running as background tasks (i.e., Android services). One first task implements components for capturing the mobile context and reasoning on it thanks to the semantic reasoning engine deployed on it. The second one embeds the OSGi Framework. Both components interact with each other for context acquisition, handling, reasoning and domain services provision.

The OSGi Framework contains all bundles implementing the ITS’s components and ontologies. To allow loose coupling between bundles’ services, relevant services are advertised in the OSGi services registry. Semantic descriptions of those services are also updated within the OSGi bundles/services ontology to allow further reasoning on the services’ semantic capabilities and goals which could be queried thanks to the reasoning engine service. So, core bundles of each module are developed while other domain specific functionalities could be added accordingly to the specific domain needs or to the user’s mobile context.

Services are organized on infrastructure services (the installer service, the update service, etc.), module managers services corresponding to the ITS’s modules as well as specific ITS services (e.g., knowledge assessment service, user interface service, learning process manager service).

Specific ITS Ontologies are used jointly to their corresponding ITS modules (e.g., the learner module makes use of the learner ontology which is part of the context ontology for handling one’s learner specificities and for reasoning.
and providing the best fitted services; The domain ontology specifies the concepts of the domain to be taught (learned). It is used by the domain module bundles, etc.). While the more generic ontologies as the Context ontology, the Goal ontology and the Bundles/Services ontology are organized in the semantic layer.

Accordingly to context and decisions made on it the ITS could exchange Bundles and resources either from peer’s devices or over the air from distant repositories. These could eventually be deployed on the Cloud.

![Proposed architecture](image)

**Figure 6. Proposed architecture**

**Implementation and validation**

In this section as a proof of concept, an implementation and a use case that illustrates the provided solution are presented.

![Proposed reading activity](image)

**Figure 7. Proposed reading activity**
Firstly, to implement the proposed mobile ITS app, following software are used; the Android SDK for Android app development, the Felix OSGi framework for OSGi bundles deployment and execution, Protégé for ontology development and AndroJena plug-in for reasoning among and querying ontologies.

Several mobile learning scenarios are possible. They begin when the learner initialize a learning session. The system proposes hints, exercises or possible useful expressions. The learner uses her/his specific interface to send results to the system. The system assesses those results and returns feedbacks.

The application (Figure 7) begins the learning scenario by showing a paragraph on which the student will be asked some questions. Interface (Figure 8) proposes to the learner a list of answers and requests her to choose the answer she finds suitable to the question.

```
PREFIX ns: <http://www.owlontologies.com/OntologyGoal.owl#>
PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
PREFIX rdfs: <http://www.w3.org/2000/01/rdf-schema#>
PREFIX owl: <http://www.w3.org/2002/07/owl#>
PREFIX xsd: <http://www.w3.org/2001/XMLSchema#>
PREFIX tg: <http://www.turnguard.com/functions#>
WHERE {
  ?Goal rdf:type ns:Goal .
  ?Goal ns:Description ?Description .
  ?Goal ns:GoalHas ?GoalHas ,
  ?Capability rdf:type ns:Capability ,
  ?Capability ns:Has_Assumption ?Has_Assumption .
  ?Assumption ns:Description ?D_Assumption .
  FILTER (?GoalHas = ?Capability) .
  FILTER (?Has_Assumption = ?Assumption) .
  FILTER (?Has_Effect = ?Effect) .
  FILTER (?Has_Postcondition = ?Postcondition) .
  FILTER (?Has_Precondition = ?Precondition) .
  FILTER (?Description = 'Code Scan') .
}
```

Figure 9. SPARQL Query for service discovery
In case that the user is moving and the Context acquisition service detects, thanks to location service based on GPS that the learner is very close to the library building where practical books are available. The system notifies the learner who decides to enter the library building. Unfortunately the mobile app deployed on the learner’s device does not contain the client’s service that could scan books’ Barcode or QR Code to obtain much more information on a book on hand. Fortunately, a learner’s peer’s is very close and via specific authorization, a SPARQL query of Figure 9. Lines 9-30 using the goals and services ontologies is sent to the peer’s device. The purpose is to find the relevant service’s URL having equivalent capabilities to the given goal.

The Figure 10 illustrates that two (bundles) having the corresponding services are available and the learner’s device could again choose one of them to download.

The downloaded bundle is automatically installed and started in OSGi Framework.

Conclusion and future work

Due to diversity of disabilities, the need to individually support each user and the lack of sufficient specialized and qualified human resources, one size fits all approaches are no more suitable.

Research realized in this paper which was based on literature review as well as scenario elaboration and analysis have concluded that even if in one-on-one learning systems the content and the learning approach may be easily adapted, learning/supporting services requiring new development or reconfiguration are not easily rendered available, especially due to the lack of standards promoting unified ways to develop services and hence to re-use them.

To overcome these issues, dynamic adaptability as well as mobility issues of ITS features at runtime have been addressed. The proposed solution presents several advantages. First, the learning approach provided, allows the learner with specific needs to take advantages of learning services both in formal or informal settings. This was possible thanks to the use of several specific domain ontologies that are uploaded accordingly to the user’s context, specific disabilities and situation.

Second, it allows fine grained services development and deployment at runtime as well as semantic discovery, composition and execution of those services. Third, it allows formal knowledge representation about the ITS’s components, content as well as the user’s mobile context and her specific needs and disabilities. Therefore, semantic reasoning and inferences are rendered possible over that knowledge. Thanks to the underlying OSGi framework which is mainly intended to small devices, ITSs components and services based on the solution are lightweight and so the ITS’s configuration and re-configuration could be customized or adapted accordingly to the user’s context.

Finally, the specific manager allocated to each module of the ITS, allows automatic data collection about the system’s behavior, self monitoring, reasoning and therefore provides an efficient way to draw conclusions and operate adaptation of the proposed solution.

Possible future extensions of this work are to integrate text-to-speech as well as intelligent conversational behavior between the system and the learner. Currently, an extension is being done to create possible interactions of the system with mobile affect devices and therefore collect other contextual data about the user. Experiments dealing
with more frequent change of context have to be realized and evaluation of time and performances during services exchanging between peers should be done.

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Using Educational Games for Sign Language Learning - A SignWriting Learning Game: Case Study

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ABSTRACT

Apart from being used as a means of entertainment, computer games have been adopted for a long time as a valuable tool for learning. Computer games can offer many learning benefits to students since they can consume their attention and increase their motivation and engagement which can then lead to stimulate learning. However, most of the research to date on educational computer games, in particular learning versions of existing computer games, focused only on learner with typical development. Rather less is known about designing educational games for learners with special needs. The current research presents the results of a pilot study. The principal aim of this pilot study is to examine the interest of learners with hearing impairments in using an educational game for learning the sign language notation system SignWriting. The results found indicated that, overall, the application is useful, enjoyable and easy to use: the game can stimulate the students’ interest in learning such notations.

Keywords

People with hearing disabilities, Avatar technology, Deaf education, Educational games, Technology-assisted learning

Introduction

As for any other group, education is critical to expanding the life prospects of people with hearing disabilities since it helps them to gain knowledge they need to succeed in today’s communities and the world of information and communication. Unfortunately, despite serious efforts to date, many deaf students continue to experience difficulties in achieving normative standards of literacy. The most recent available data provided by the World Federation of Deaf indicate that the enrollment rate and literacy achievement of deaf children is far below the average for the population at large and that there is at least 80% of the world’s 70 million deaf people are illiterate or semi-literate. How literacy is taught, utilized, and potentially mastered is, in fact, one of the most discussed, researched, and highly contentious topics in the field of deaf education and deaf studies (Harris & Marschark, 2011). Among the most notable results which have been drawn by different researchers in this field is that high levels of illiteracy and low academic achievements among these hearing impaired students are associated to the discrepancy between their incomplete spoken language system, and the demands of writing and reading through a speech-based system (Geers & Hayes, 2011; Nussbaum et al., 2012; Zamfirov & Saeva, 2013). It is important to know that reading and writing require two related capabilities; firstly you must be familiar with a language and secondly, you must understand the mapping between that language and the printed word (Chamberlain & Mayberry, 2000). Deaf and Hard of Hearing learners (DHH) are disadvantaged on both counts. For example, learning to read requires DHH learners to learn the mapping between the spoken language and the printed words, and this is not easy for them because they do not have access to phonological code and many do not know the language well since it is often considered as a second language for them (Goldin-Meadow & Mayberry, 2001).

Actually, providing these learners with a suitable writing form in their first language could be a help to them. It has been demonstrated that an appropriate sign language written form can offer deaf learners the possibility to process written linguistic information provided in a syntactic structure that reflects the structure of the corresponding sign language. Moreover, such written form can be very useful to improve the ability of these signers to comprehend and acquire the written versions of oral languages (Vendrame et al., 2013; Guimarães et al., 2014). At present, SignWriting (SW) is already one of the best known writing systems which are currently being used as an educational tool in several pilot projects around the world. This system deemed adequate to transcribe the visual nature of signing through highly iconic symbols and its practical usage in literacy education has had a great impact on the education of deaf children (Kato, 2008). Nonetheless, it’s fair to say that a training to learn to interpret such static
transcriptions is needed for novice readers, who are accustomed to the use of their preferred language in a visual-gestural modality.

Fortunately, the emergence of Information and Communication Technology (ICT) has brought new hopes and opportunities for these learners. The rapid evolution of a vast range of newer digital technologies has made the role of such assistive technologies, in educating deaf children, even more crucial than ever before. For instance, the adoption of visual forms of ICTs (e.g., immersive multimedia, 3D animation, virtual reality and video conferencing) within educational settings can facilitate the acquisition and absorption of knowledge, increase learner motivation and engagement, and enhance teacher training (Hameed, 2007; Haddad & Jurich, 2002; Passey et al., 2004).

Another promising and interesting alternative to reinforce learning experience, today, is the use of educational games. Indeed, it has been proved by experience that the usage of educational games can consume the attention of learners and increase their motivation and engagement which can then lead to stimulate learning (Bourgonjon et al., 2011; McClarty et al., 2012). Educational games can increase creativity, improve self-confidence and provide visual, tactile and intellectual stimulation (Griffiths, 2002). However, it should be noted that most of the research to date on educational games focused only on learner with typical development. Rather less is known about designing educational games for learners with special needs, including the Deaf and Hard of Hearing (DHH).

In the current research, we are interested in combining these two approaches to benefit from an effective and useful educational game geared toward the DHH learners. Indeed, we believe that the involvement of ICT, especially virtual avatar technology, into a learning game could be a suitable solution to stimulate the learning interest of these disabled students and make the learning process more meaningful and enjoyable. The proposed game, namely MemoSign, aims essentially to foster and promote the vocabulary acquisition for DHH learners in both signed and spoken languages. More specifically, MemoSign would offer an additional support to learn the sign language written form, SignWriting (Sutton, 2015), and this by rendering its notations’ content in visual-gestural modality through a 3D signing avatar. We will seek, through the present study, to examine the deaf learners’ interest in using such educational game for learning SignWriting notations and new vocabularies. In particular, we want to know whether the game is helpful and appreciated for them. Thus, the research question of the present study is the following: What is the students’ opinion regarding the usability of the MemoSign game?

The remainder of this paper is organized as follows: the next section starts by highlighting the main benefits of using avatar technology and computer games within the educational process. The section 3 contextualizes the contribution by reporting related works. Section 4 presents the new educational game for DHH learners. Section 5 describes the evaluation method and the empirical results. Finally, section 6 concludes the paper with a summary of the work and future research directions.

**Literature review**

Today, the emergence of assistive technologies has opened great opportunities for improving the learning performance of students with hearing disabilities. These technological tools have a great potential to enhance the quality of education and this by adopting appropriate techniques suited to the learners' abilities. We will address in this section a particular view to the benefits of using avatar technology and computer games within education.

**The educational benefits of avatar technology**

For students with severe hearing disabilities, the use of computer animated avatars within educational contexts is proving to be successful and holds particular promise. The 3D characters can act as a powerful communication medium for deaf learners to display knowledge in sign language and make instructional materials completely accessible to them (Vesel, 2005; Adamo-Villani & Hayward, 2010; Kipp et al., 2011, Jaballah & Jemni, 2013). Besides, by appearing on screen as embodied entities, whether humans, or anthropomorphized characters and animals, these graphical entities can increase effectively learners’ attention and motivate them to keep interacting with the content presented (Mahmood & Ferneley, 2006; Deuchar & Nodder, 2003). It may seem, at the first glance that recording a real signer with a video camera would be a reasonable approach, but digitized video lacks the
flexibility of avatar animation systems. In fact, 3D animation systems provide a low-cost and effective means for adding sign language translation to any type of media because animation is actually a much easier type of data than video to store. Signing avatars can be produced anywhere at any time with a relatively low cost in order to be easily integrated in any educational application.

The educational benefits of computer games

Despite the controversy surrounding the usefulness of computer games in encouraging learning (Barlett et al., 2009; Prot et al., 2012), a large amount of evidence proves that such games could be an effective way to impart knowledge and provide personalized learning opportunities for students. Many researchers working in the field of game studies argue that besides being a strong motivational attractive, the usage of such software category as learning objects can amplify the students’ potential of exploration and imagination, providing moment recreation to didactics, involving investigation, reflection and learning (Mitchell & Savill-Smith, 2004; Egenfeldt-Nielsen, 2007; Silveira et al., 2011). In this sense, Papastergiou (2009) and Gee (2006) claimed that computer games are hugely successful in engaging and motivating learners to spend more time and effort on problem solving and learning skills. Nevertheless, it is important to point out that designing and developing educational games that could effectively support the process of learning, need to satisfy the following criteria: the educational games should be designed properly, meet the abilities of the students, integrated with curriculum and classroom activities, and monitored by parents or teachers (Bourgonjon et al., 2011).

Related work

Despite the effectiveness of computer games in enhancing learners’ motivation and engaging them in learning, the majority of the practice and research around the use of these games has been undertaken only with students with typical development. Designing appropriate educational games for learners with special needs is unfortunately less known. We will present in this section a brief overview of existing works that address the development of computer games for the DHH learners.

CopyCat

CopyCat is an interactive educational video game to develop American Sign Language skills (ASL) in younger children. Using gesture recognition techniques, CopyCat allows deaf children to communicate with the computer using ASL and encourages them to practice signing in an enjoyable way (Henderson et al., 2005). CopyCat refers here to Iris, the main character of the game. Iris is a white cat whose kittens are hiding in the backyard. The player’s role is to help Iris find her kittens by signing a phrase such as “Black kitten under the chair.” The game interface includes a tutorial video demonstrating the correct signs, live video (providing input to the gesture recognition system and feedback to the child via the interface), and Iris the cat, to execute the child’s instructions. It should be noted that, before playing the game, the child must wear colored gloves with wrist-mounted accelerometers and sit in front of the computer equipped with a video camera for the computer vision recognition system.

Sign my World

Sign my World is a mobile video game developed by the Seek and Sign research project to aid deaf children to learn the Australian Sign Language (Auslan). The game aims to support deaf children to be familiar with the appearance of common nouns and verb signs. The game interface has a 2D cartoon like style and bright colors. It began as a single sample area (a bedroom) containing a number of interactive objects. When an interactive object is clicked, an image and word are displayed, as on a flash card; followed by the video of the Auslan sign for that object. This is intended to allow the child to make associations between the object and the sign (Korte et al., 2012).
Virtual Sign Game

Virtual Sign Game is a didactic game developed by the Virtual Sign Project with the collaboration with the research group GILT (Graphics, interaction & learning technologies). The main goal of this game is to facilitate the learning of the Portuguese sign language and to improve the dexterity of those who already know it (Escudeiro et al., 2014). In Virtual Sign game, the player controls a synthetic character that interacts with various objects and non-player characters with the aim of collecting several gestures from the Portuguese Sign Language. These gestures can then be represented by the character in order to provide the user a chance to visualize and train the various existing gestures. To improve the interaction between the player and the main character, a VirtualSign Translator has been connected to the game using a translator Kinect and gloves. The VirtualSign application detects and translates the gestures that the user makes, saving the one with higher probability of success.

To the best of our knowledge, there have been no studies evaluating the impact of using such games on learning sign language for DHH learners. Besides, none of these games are available on the web and thus do not provide a social experience for their players. Indeed, due to the use of special equipment and non-standard ways in which applications are developed, the majority of these educational tools is limited to academic and research environments.

MemoSign: A new learning game for deaf learners

In order to overcome the serious difficulties they face in acquiring academic skills in spoken language and helping them to adopt an appropriate manner for transcribing their first language in a written form, we propose in the present section a learning game suitable to the learning needs of deaf and hearing impaired students. The learning game is called MemoSign; it federates the use of a learning version of the Memory Match Game, avatar technology, and the sign language writing system SignWriting (Figure 1).

Learning version of Memory Match Game (LMMG)

The original version of Memory Match Game (Zwick & Paterson, 1993) consists of several cards that have pictures on one side. The number of cards is always even. Typically same picture is printed on two cards. All of the cards are mixed up and laid face down on a surface. The game is designed for a single player, although the two player mode is available. In each turn, the player selects a card to flip it over. If the next card selected by the player matches the first card, both cards disappear from the surface. The objective of the game is to turn over pairs of matching cards with an aim to get rid of all cards in the least possible trials. In the original version of the Memory Match Game, all cards hold only visual information. However, in the learning version of this game (Khenissi et al., 2014), which is available online at: http://www.egresearch.info/edugame/LVMMG/index.html, other types of information has been added. Precisely, it uses eight types of pair of cards: Visual – Visual; Visual – Word; Visual – Sound; Word – Word; Word – Sound; Sound – Sound; Calculates – Calculates and Calculates – Sound.
Synthesizing SignWriting notations

SignWriting (SW) is a writing formalism developed at the University of Copenhagen by Valerie Sutton in 1974 with the intention to record signed languages for research purposes. Over the years, such formalism has evolved with the aid of many deaf people and it has proven to be effective and easy to use in their daily lives since it makes it possible to read, write and type any signed language by hand or by computer. This led to SignWriting being widely accepted by different deaf communities worldwide and making its way into education (Flood, 2002). Nowadays, more than fifteen countries (including France, Italy, USA, Portugal, Canada, Brazil, Germany, Tunisia, Jordan) have their own SW dictionary which is used to aid literacy. Figure 2 shows an example of SignWriting notation.

![Figure 2. The SignWriting notation of the sign “house” in Tunisian Sign Language](image)

One of the most important features that make Sutton system very promising compared with other existing notation systems, is that it can express by itself any signed sequence, without further annotations in a written vocal language (Borgia et al., 2012). Signed words written in SignWriting are created by compounding symbols of a highly pictorial design for hand shapes, palm orientation, body parts, facial expressions, contacts, and finger movements (Figure 2). However, despite this featural script closely visually resembles the concrete signs, a training to learn to interpret its static transcriptions is needed for novice users who are accustomed to the use of their sign language in a visual-gestural modality. The bi-dimensional representation of such notations may inadvertently create confusion and ambiguity to them since the four-dimensional nature of signing (three-dimensions of space and one of time) cannot be fully reflected into a symbolic transcription. To offer a closed signing for such notation and make its content completely accessible to deaf readers, an avatar based system, called tuniSigner (Bouzid & Jemni, 2013), was used to synthesize sign language animations from transcribed gestures. A 3D human character, as shown in Figure 3, displays and interprets the SignWriting notation content in natural and comprehensible movements.

![Figure 3. The interpretation of the sign “house” via tuniSigner](image)

tuniSigner system includes essentially three main stages to render sign language animated sequences (Figure 4). At the first stage, the system starts by parsing the SWML file which is an XML-based encoding of SW notations. All information associated with the input SWML file is processed in order to identify the significant features which compose the internal structure of the sign. At the second stage, the system provides an explicit linguistic description incorporating all phonetic details needed to describe the avatar motion in the form of postural and transitional segments. At the third stage, the system ensures the conversion of the obtained sign description to SML (Sign Modeling Language), a skeletal representation of sign language gestures which has been developed especially for WebSign application (Jemni & Elghoul, 2007). SML can describe any signed utterance in terms of translation or Euler rotation of a group of joints, such as the neck, wrist, hand fingers, eyebrows, eyelids, jaw and so on. Such script is interpreted then automatically by an animation engine to generate the corresponding animations (Bouzid & Jemni, 2014a; Bouzid & Jemni, 2014b).
Figure 4. An overview of tuniSigner system’s architecture

**MemoSign game**

MemoSign is an educational game designed to foster and promote the vocabulary acquisition of any written language, both spoken and signed. More specifically, MemoSign offers an additional support to learn the sign language notation system, SignWriting, by rendering its notations content in visual-gestural modality through a 3D signing avatar. MemoSign exists in two versions dedicated to learning the vocabularies of English-American Sign Language and Arabic-Tunisian Sign Language. These two instances are available online at the following links: (a) http://www.egresearch.info/edugame/memosignasl/, (b) http://www.egresearch.info/edugame/memosign/. With this game, not only we are promoting the knowledge for deaf and hearing impaired learners, but we are also encouraging other hearing people to learn sign language and its written form SignWriting in order to become able to better understand this community. Indeed, the fact the game would be available online meant that it could also be used by other users interested in learning signed languages.

MemoSign is an adaptation of LMMG, it excludes the type of cards that hold voice contents since the learners to whom this game was essentially designed are learners with hearing impairments, and defines three pair of cards which are:

- **Word - SignWriting**: The first card holds written information, whilst the second card holds the translation of the word in SignWriting (SW). In this case, the learner must know the meaning of the word. After that, he/she has to seek for the correspondence of the card in SignWriting, and then select these two cards if they are similar.

- **Visual - SignWriting**: The first card holds visual content, whilst the second card holds SW information. In this case, the learner must find the relationship between the visual and SW content. Particularly, he/she has to see the visual card and read the SW information on the second card, and then select these two cards if they are similar.

- **Calculates - SignWriting**: The first card holds simple math problem content, whilst the second card holds SW content. In this case, the learner must find the relationship between the result of the calculation and the result translated on SW. Exactly, he/she has to complete the calculation on the first card and memorize the result. After that, he/she has to look for the card that holds the result of the calculation translated in SW notation.

When the player flips a card that holds a SignWriting notation, a 3D virtual signer starts the interpretation of its notation content in visual-gestural modality. The incorporation of a virtual avatar in the MemoSign game could be particularly beneficial for two main reasons. In the one hand, a signing avatar could offer a support for players to understand and grasp the SignWriting notation content, and this by displaying and interpreting the transcribed gestures in natural and comprehensible movements. In the other hand, rendering an animated human like character could certainly increase and promote the engagement, fun and motivation of disabled learners. As mentioned by (Peterson, 2005), avatars allow the user to take on a visible persona within a virtual world, affording them the opportunity to engage in surreal and imaginary experiences that transcend the actual world in which they live. Hence,
avatar technology can give the DHH learners the opportunity to master content in a way that meets their needs and to practice skills until they experience success. Figure 5 presents a screenshot of MemoSign game, it shows that a learner has selected randomly two cards: the first one holds visual information whilst the second card holds SignWriting notation with a 3D avatar that interprets the transcribed gestures in natural movements.

![Figure 5. Screenshot of MemoSign game](image)

**The pilot study: Methodology**

We seek, through this pilot study to examine the deaf learners’ interest in using the educational game MemoSign for learning SignWriting notations and new vocabularies. In particular, we want to know whether the learners enjoy the game, think it might be useful and learn new vocabularies.

**Participants**

The evaluation was performed in the Tunisian Association for deaf people (ATAS) over three sessions on separate days. ATAS which is located in Ezzahra, a region in northern Tunisia, offers specialist educational services for children with hearing impairments basing on the use of SignWriting system. The sample consisted of 9 deaf learners, 7 boys and 2 girls, aged 9 to 16 years old. The demographic characteristics of these participants are shown in Table 1. These characteristics include age, gender, degree of hearing loss and first language.

<table>
<thead>
<tr>
<th>Demographic characteristics</th>
<th>Frequency</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>7</td>
<td>77.77</td>
</tr>
<tr>
<td>Female</td>
<td>2</td>
<td>22.22</td>
</tr>
<tr>
<td>Age</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Under 10 years old</td>
<td>3</td>
<td>33.33</td>
</tr>
<tr>
<td>10-13 years old</td>
<td>4</td>
<td>44.44</td>
</tr>
<tr>
<td>14 years old and over</td>
<td>2</td>
<td>22.22</td>
</tr>
<tr>
<td>Degree of hearing loss</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Moderate</td>
<td>3</td>
<td>33.33</td>
</tr>
<tr>
<td>Severe</td>
<td>4</td>
<td>44.44</td>
</tr>
<tr>
<td>Profound</td>
<td>2</td>
<td>22.22</td>
</tr>
<tr>
<td>First language</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sign language</td>
<td>9</td>
<td>100</td>
</tr>
<tr>
<td>Spoken language</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Table 1. Demographic data of the participants
Procedure

The experimental procedure consisted of three parts: a preparatory phase, a learning phase, and an analysis phase.

**Phase 1: Training session**

In the preparation phase, two experts provided a short training session on how playing the game to participants. Given the unique needs of these children, the training session included the intervention of a teacher and a sign language interpreter who play the role of intermediaries between experts and deaf participants for translating spoken language to sign language and vice versa. Besides, the experts have coordinated with the teacher about the vocabularies that will be presented in the MemoSign game.

**Phase 2: Participants play the game**

The experts arranged three learning sessions with the association ATAS. During each session, each participant was invited to play the game, while the experts observed their reaction and behavior throughout the process. The types of cards used in the game are (Visual, SignWriting) and (Word, SignWriting).

**Phase 3: Collecting and analyzing data**

The third phase consists of collecting and analyzing qualitative data from the experiment. The methods chosen for that purpose were observations and interviews.

Indeed, the playing and training sessions were video-recorded. Two video cameras were used; the first one is a facial camera with screen recorder that records the participants’ facial reactions in parallel of his/her interactions with the game, while the second one was a side camera that records all participants’ actions during the game-play. Figure 6 shows the participants while playing the MemoSign game. At the end of study, the video recordings will pass to an expert to analyze and note observations using an observation sheet. The observation sheet is composed of 3 sections: difficulty of using the game, engagement and fun, behavior during the game. Every section had a free space in which the expert could take notes about the participants while playing MemoSign.

On the other side, each participant was requested to answer questions in the form of an interview after finishing playing. The interview is monitored by the experts with the help of the teacher and her assistant.

*Figure 6. The deaf participants while playing MemoSign*
Measurements

The data for this study were gathered by means of a questionnaire. The questionnaire included four major sections derived from two validated questionnaires which are: The technology acceptance model questionnaire (Davis, 1989) and USE (Usefulness, Satisfaction and Ease) questionnaire (Lund, 2001). The first and the second sections of the questionnaire were related respectively to the Usefulness (U) and Ease of Use (EOU) of the learning game. While the third and fourth sections examine the users’ Satisfaction (S) and Ease of Learning (EOL). The questions that belong to U, EOU, EOL, S, are cited in the Table 2. All sections are based on a 3 point Lickert scale, ranging from 1 (“agree”) to 3 (“disagree”).

<table>
<thead>
<tr>
<th>Sections</th>
<th>Questionnaire items</th>
</tr>
</thead>
<tbody>
<tr>
<td>Usefulness</td>
<td>It is useful</td>
</tr>
<tr>
<td></td>
<td>It meets my needs</td>
</tr>
<tr>
<td></td>
<td>It helps me to concentrate on my study</td>
</tr>
<tr>
<td>Ease of use</td>
<td>It is simple to use</td>
</tr>
<tr>
<td></td>
<td>I can use it successfully every time</td>
</tr>
<tr>
<td></td>
<td>It is user friendly</td>
</tr>
<tr>
<td>Ease of learning</td>
<td>It helps me to learn vocabulary easily</td>
</tr>
<tr>
<td></td>
<td>I easily remember what I have learnt</td>
</tr>
<tr>
<td></td>
<td>It helps me to understand the SW notations</td>
</tr>
<tr>
<td>Satisfaction</td>
<td>I am satisfied with it</td>
</tr>
<tr>
<td></td>
<td>I feel I need to have it</td>
</tr>
<tr>
<td></td>
<td>It is fun to use it</td>
</tr>
</tbody>
</table>

Table 2. The questions that belong to U, EOU, EOL and S

Results

The answers given by the participants in the questionnaire were treated as descriptive statistics. The obtained results are presented in Table 3.

<table>
<thead>
<tr>
<th>Sections</th>
<th>Agree</th>
<th>Neutral</th>
<th>Disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>Usefulness</td>
<td>88.88%</td>
<td>11.11%</td>
<td>0%</td>
</tr>
<tr>
<td>Ease of use</td>
<td>100%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Ease of learning</td>
<td>100%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Satisfaction</td>
<td>77.77%</td>
<td>0%</td>
<td>22.22%</td>
</tr>
</tbody>
</table>

Table 3 reveals that the participants’ respondents generally hold positive attitudes towards using MemoSign game. The noticeable finding from this result is related basically to EOU and EOL items. In fact, all participants declared that the level of difficulty of the game was low and that game rules were easy to follow. The simplicity of the educational game encourages and motivates them to use it every time. Likewise, all participants claimed that playing MemoSign game was generally fun and could help them learn and retain new vocabularies in both spoken and signed languages more easily. However, although the respondents’ views are generally positive, participants were not totally satisfied. We can see that only 77.77% of them stated that are satisfied with the game and 22.22% were not satisfied. More importantly, only 88.88% of participants think about the usefulness and the effectiveness of the game in supporting their vocabulary building. Those participants stated that the use of the educational game would make lessons more interesting than traditional teaching method, because it keeps them concentrated and engaged in the learning process. However, the rest of participants are doubtful whether the game can enhance their vocabulary learning. In general, this group of participants includes those aged 14 years old and over.

Based on data gathered from the video recordings and experts’ observations, additional analyses have been performed. For example, the duration of the training session, the duration of the playing sessions and the duration of the interview were analyzed using descriptive statistics and summarized in Table 4.
Table 4. Descriptive statics of the duration of the training session, the duration of the playing sessions and the duration of the interview

<table>
<thead>
<tr>
<th>Duration</th>
<th>Number of participants</th>
<th>Minimum (minute)</th>
<th>Maximum (minute)</th>
<th>Mean (minute)</th>
<th>Std. deviation (minute)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Training session</td>
<td>9</td>
<td>4.39</td>
<td>8.25</td>
<td>5.7167</td>
<td>1.20846</td>
</tr>
<tr>
<td>Playing session (Day 1)</td>
<td>9</td>
<td>3.17</td>
<td>6.55</td>
<td>4.8056</td>
<td>1.14317</td>
</tr>
<tr>
<td>Playing session (Day 2)</td>
<td>9</td>
<td>3.02</td>
<td>7.47</td>
<td>4.7489</td>
<td>1.51561</td>
</tr>
<tr>
<td>Playing session (Day 3)</td>
<td>9</td>
<td>3.22</td>
<td>6.39</td>
<td>4.64</td>
<td>1.12116</td>
</tr>
<tr>
<td>Interview</td>
<td>9</td>
<td>2.43</td>
<td>4.31</td>
<td>3.3733</td>
<td>0.62322</td>
</tr>
</tbody>
</table>

Table 4 shows that the mean of the training session is greater than those obtained in the three playing sessions, this could be explained by the fact that DHH learners have adequate time to assimilate the game rules and then apply them. The second observation derived from the Table 4 is that the means of the playing durations decreased from a session to another. For example, the mean of the playing duration on training session is 5.7 minutes whilst the mean of the playing duration on session 3 is 4.64 minutes. These findings indicate that participants become skillful on game playing due to its simplicity.

The analysis of the participants’ reactions during the game-play (filmed by two video cameras) which was done by the expert is presented in Table 5.

Table 5. Result of evaluation of each participant

<table>
<thead>
<tr>
<th>Difficulty of using the game</th>
<th>Engagement and fun</th>
<th>Behavior during the game</th>
</tr>
</thead>
<tbody>
<tr>
<td>Easy</td>
<td>Medium</td>
<td>Difficult</td>
</tr>
<tr>
<td>Participant 1</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Participant 2</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Participant 3</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Participant 4</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Participant 5</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Participant 7</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Participant 8</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Participant 9</td>
<td>x</td>
<td>x</td>
</tr>
</tbody>
</table>

As shown in Table 5, the expert noted that all participants, whatever their degree of hearing loss, handled the game interface without difficulties. This proves that MemoSign is easy to use and it suits all students with a hearing loss. Besides, the expert observed that the majority of participants tries to mimic the avatar movements during the game-play, and they succeeded to do this correctly. This proves that the incorporation of the signing avatar in the game helped them to understand correctly the transcribed notations, and thus facilitate the learning process. Moreover, the expert noticed that the participants’ behavior during the game was very good. He found that the majority of participants was having fun while playing the game.

Discussion and conclusion

Given their specific disability, learners with hearing impairments were often denied from using computer game for learning purposes like their hearing peers. There have been, even timidly, few attempts that focusing on developing educational games geared towards this community. The ultimate aim of the current research is to examine the deaf learners’ interest in using MemoSign, an educational game for learning SignWriting notations and new vocabularies.
The results of the present pilot study revealed that the game: (a) is easy, entertaining and pleasant; (b) it is well liked and accepted by students as a more satisfying and pleasurable teaching method than the traditional lessons; (c) it offers an innovative approach to learning SignWriting notations; and thus can constitute a useful tool for teaching the vocabularies of signed and spoken language.

Participants’ comments on the learning game during the interview were very encouraging. Most participants wish that they have more opportunities to use the MemoSign game as a learning tool during the session of learning vocabulary. They also wish that the learning game will be available on the social network Facebook. These findings provide evidence that students had strong motivation to use this game to learn. More importantly, participants found that the use of this educational game is more satisfying than traditional classroom lessons, since it can raise their stimulus and desire to acquire new vocabularies in an enjoyable way. For example, some participants admitted they gained a lot from the repetition of selecting words in the game. Regarding the opinion of the teacher and her assistant about the game, it was quite positive, as they considered it to be friendly and easy-to-use. Indeed, this result implies that MemoSign game could offer a possibility to complement traditional instructional strategies for reinforcing the students’ lessons.

The results of the expert’s analysis of video recordings support the ones obtained in the interview. During the game, participants were very engaged and fully involved. Particularly, they showed a great interest and enthusiasm for simulating the avatar interpretation. Clearly, this finding proves the usefulness of avatar technology in supporting the learning process for these learners and making the learning process easier. Hence, regarding the research question (What is the students’ opinion regarding the usability of the MemoSign game?), it was concluded that DHH learners were quite positive toward using the new educational game.

It is important to stress that MemoSign game exists in two versions dedicated to learning the vocabularies of English-American Sign Language and Arabic-Tunisian Sign Language. A mobile version of this game exists too in order to complement the existing Browser Game. Indeed, providing a learning version of the game on mobile devices for deaf gamers offers unique opportunities to deliver learning content in authentic learning situations (De Jong et al., 2010).

The present study also has some limitations. It was designed to be preliminary and the sample is too small to offer useful data. In order to further generalize and strengthen the validity of the results, we aim to conduct more experiments and classroom field studies. Further, we intend to set up an interactive game generator to allow teachers, desiring to develop computer-based educational materials which target DHH learners, to personalize the different features of the game and this by specifying the target words, SW notations, images and SL animations.

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References


An Innovative Approach to Scheme Learning Map Considering Tradeoff Multiple Objectives

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ABSTRACT

An important issue in personalized learning is to provide learners with customized learning according to their learning characteristics. This paper focused attention on scheming learning map as follows. The learning goal can be achieved via different pathways based on alternative materials, which have the relationships of prerequisite, dependence, and sequence. Besides, owing to distinct learner characteristics, different learning materials with various forms have distinct effects on learners, such as learning performance (benefit objective), learning time (cost objective), and so forth. Accordingly, scheming learning map is not only the NP-hard combination problem, but also the tradeoff multiple objectives optimization. More importantly, it is not only impossible for instructors to scheme the fitting learning maps for learners, but also difficult and time-consuming for learners to scheme their fitting learning maps by themselves. Hence, this paper first proposed an innovative approach based on enhanced genetic algorithm (GA) with Technique for Order Preference by Similarity to Ideal Solution (TOPSIS), to facilitate the search for the near-optimal solution of learning map. Moreover, a web-based learning management system based on the proposed approach was developed to help instructors facilitate the customized learning itineraries for learners. The experimental results from simulations showed that, not only in terms of search effectiveness and solution quality the proposed approach significantly is superior to a genetic algorithm and a Random method, but also in terms of search efficiency the proposed approach significantly is superior to a genetic algorithm. That is, the developed system with the proposed approach is able to efficiently scheme the learning map with reliable and high quality. Consequently, the instructors and learners can concentrate on their tasks.

Keywords
Personalized learning, Scheming learning map, Tradeoff multiple objectives, Genetic algorithm, TOPSIS

Introduction

Personalized learning has been a popular trend in the field of e-learning. Owing to learners have different learning abilities, knowledge, and learning performance (Tan, Shen, & Wang, 2012), personalized learning aims to fit the needs, goals, talents, and interests for individual learners (Klašnja-Milićević, Vesin, Ivanović, & Budimac, 2011). To date, many researchers have carried on studying personalized learning with advanced computer technologies, for examples, Hsu (2008), and Hsieh, Wang, Su, and Lee (2012) have developed the English learning recommender systems to provide learners with appropriate materials according to their profiles and thus help them better English abilities and learning motivations. Moreover, Hwang, Sung, Hung, and Huang (2013) have indicated that learners having learning style-fit materials better learning achievements significantly.

With the rapidly grown Internet, e-learning have explosive learning resources and materials, the customized learning has become an important issue in personalized learning (Lin, Yeh, Hung, & Chang, 2013). Having a learning path to be appropriate for all learners is impossible (Al-Muhaideb & Menai, 2011; Chen, 2009), and the inappropriate curriculum sequencing leads to cognitive overload even disorientation (Chen, 2008). Such issue has attracted an increased research interest, for examples, course generator is to assemble the courses sequence depending on learner’s competence and learning goal (Ullrich & Melis, 2010), and learning path is to provide learning contents with pedagogical requirements meeting learner’s profile and preference (Al-Muhaideb & Menai, 2011). Moreover, Garrido and Oñaindia (2013) have indicated the challenge is to select the proper learning objects, define their relationships, and assemble their sequencing according to the learning goal and learner’s status.

In the past, many researches have been done on customized learning regarding course composition and learning path considering learning goal, material difficulty, concept continuity and balance, limited time, learning ability, learner’s
profile, preference, need, test result, knowledge, cognitive style, learning style, and so on. Chen (2008) have utilized genetic algorithm and later Chen (2009) have combined it with ontology-based concept map. Chen and Duh (2008) have proposed the fuzzy item response theory to concern uncertain responses. Kontopoulos, Vrakas, Kokkoras, Bassiliades, and Vlahavas (2008) have used artificial intelligence and semantic web technology. Ullrich and Melis (2009) have presented a framework with pedagogical knowledge and later Ullrich and Melis (2010) have constructed a course generator with six different scenarios. Wong and Looi (2009) have presented the rule-based prescriptive planning and ant colony optimization-based inductive planning. Wang and Tsai (2009) have proposed a greed-like materials sequencing approach with discrete particle swarm optimization. Wang, Tseng, and Liao (2009) have employed the decision tree algorithm.

Moreover, Carchiolo, Longheu, and Malgeri (2010) have proposed a model to search for reliable resources suggested by peers. Chu, Chang, and Tsai (2011) and Li, Chang, Chu, and Tsai (2012) have adopted genetic algorithm and particle swarm optimization. Klašnja-Milićević et al. (2011) have applied aprioriall algorithm. Jeong, Choi, and Song (2012) have adapted the decision support system. Tan et al. (2012) have employed genetic algorithm with a layered topological sort algorithm. Chang and Ke (2013) have proposed a forcing legality operation in genetic algorithm to increase search efficiency. Durand, Belacel, and LaPlante (2013) have utilized the graph theory. Garrido and Onaindia (2013) have used planning techniques satisfying the temporal and resource constraints. Lin et al. (2013) have utilized hybrid decision trees. Furthermore, in the emerging u-learning learners interact real-world learning objects by context-aware technology (Hwang, Kuo, Yin, & Chuang, 2010b). Hwang, Chu, Shih, Huang, and Tsai (2010a) have indicated the challenge is to provide personalized supports to guide learners, and several works have been done on customized u-learning (Chen, Jin, & Huang, 2012; Chiou, Tseng, Hwang, & Heller, 2010; Hwang et al., 2010a; Hwang et al., 2010b).

However, in contrast to previous works this paper focused attention on the following. The learning goal can be achieved via different pathways, because required concepts on the way can be learned via alternative materials. Besides, the relationships of prerequisite, dependence, and sequence exist among pathways. Therefore, scheming learning map for learning itinerary needs to be considered. Particularly, learning materials can be formal or informal (Huang, Huang, & Cheng, 2008) and appeared in various forms. Owing to distinct learner characteristics, different learning materials with various forms have distinct effects on learners, such as learning performance (the higher the more favourable, i.e., benefit objective), learning time (the lower the more favourable, i.e., cost objective), and so forth. Unfortunately, such features are conflicting with different directions, making scheming learning map be tradeoff multiple objectives optimization. Hence, the problem of scheming learning map is, not only impossible for instructors to scheme the learning maps to fit every learner, but also difficult and time-consuming for learners to scheme their fitting learning maps by themselves. More importantly, in contrast to scheming learning map, the instructors must concentrate on the course design and the learners must concentrate on the concept learning, to increase the quality of teaching and learning.

To cope with the above problem, this paper first proposed an innovative approach and further developed a web-based learning management system, to help instructors scheme the learning maps considering tradeoff multiple objectives for learners. The similar task is complex for instructors and learners (Durand et al., 2013), but the developed system based on the proposed approach can assist in facilitating the customized learning itineraries, even in the emerging cloud learning (Despotović-Zrakić, Simić, Labus, Milić, & Jovanić, 2013). Consequently, the instructors and learners can pay more attention to their tasks to promote the quality of teaching and learning.

The proposed approach enhanced genetic algorithm (GA) with technique for order preference by similarity to ideal solution (TOPSIS). The reasons for such considerations contained: (1) The similar task have been regarded as the NP-hard combination problem (Al-Muhaideb & Menai, 2011), thus GA was selected to search for the near-optimal solution due to its excellent experiences in the past; (2) TOPSIS is good at multiple attributes decision making, so it was proper to consider for tradeoff multiple objectives while scheming learning map.

**Genetic Algorithm (GA)**

GA proposed by Holland (1975) is a population-based (represent the capability of parallel search) search technique and performs well in relation to approximating to the optimal solution, where it simulates the evolutionary theory to search the problem space, including the selection (favour the survival of better individuals), crossover (recombine
individual features), and mutation (create new individuals). After the initialization (initialize the individual status), GA repeats the selection, crossover, and mutation until the terminal condition is met. Importantly, chromosome encoding (determine the code of feasible solution) and fitness evaluation (determine the individual quality) are two keys in GAs' applications. To date, GA has been widely studied on e-learning areas, for examples, test sheets construction (Hwang, Lin, Tseng, & Lin, 2005), cooperative learning groups organization (Hwang, Yin, Hwang, & Tsai, 2008), and auto-reply accuracy optimization (Hwang, Yin, Wang, Tseng, & Hwang, 2008).

**Technique for Order Preference by Similarity to Ideal Solution (TOPSIS)**

TOPSIS proposed by Hwang and Yoon (1981) is a similarity-based ranking technique and good at multiple attributes decision making, where it defines the positive-ideal and negative-ideal solution to the ideal solution. The former is the maximum of benefit attributes and the minimum of cost attributes, whereas the latter is the maximum of cost attributes and the minimum of benefit attributes. The ranking for alternatives is based on the similarity to the ideal solution, and the best is the nearest to the former and the farthest from the latter. Accordingly, the construction of TOPSIS comprises four steps: (1) Construct a decision making matrix, (2) determine the positive-ideal and negative-ideal solution, (3) compute two measures by multiple dimensions Euclidean distance, and (4) compute the relative closeness to the ideal solution. In the past, TOPSIS has been successfully studied on many areas, for examples, financial performance evaluation for airlines (Wang, 2008), project selection for oil-fields development (Amiri, 2010), and quality ranking for e-commerce websites (Yu, Guo, Guo, & Huang, 2011).

**Problem description and notation definition**

First, each learning concept and its materials are encapsulated as the learning object. The problem is to scheme learning map for learning itinerary to achieve the learning goal. Notably, it has no need to acquire all learning objects, but has to consider multiple weighted attributes with tradeoff objectives, i.e., benefit and cost. The notations are given as follows. \( N \) denotes the set of learning objects, and different learning objects can have the same concept. \( N = \{N_q\}, 1 \leq q \leq n \). \( L \) denotes the set of links, and the links connect some of learning objects. \( L = \{L_j\}, 1 \leq j \leq l \). \( L_j = (N_a, N_b) \), \( 1 \leq a, b \leq n \), where \( N_a \) is the base learning object and \( N_b \) is the next learning object. \( A \) denotes the set of attributes, such as learning performance (benefit objective), learning time (cost objective), and so forth. \( A = \{A_i\}, A_i \in \text{Benefit or Cost}, 1 \leq i \leq m \). Finally, \( W \) denotes the set of attribute weights, and the preference for each attribute can be set accordingly. \( W = \{W_i\}, 1 \leq i \leq m \).

**Innovative approach based on enhanced GA with TOPSIS**

First, Equation 1 is used for normalization, where \( X_{ij} \) denotes the value of the \( j \text{th} \) link of the \( i \text{th} \) attribute. Figure 1 shows the flow of proposed approach, and the details are stated in the following subsections.

\[
x'_{ij} = \frac{X_{ij} - \min(X_{ij})_{1 \leq j \leq l}}{\max(X_{ij})_{1 \leq j \leq l} - \min(X_{ij})_{1 \leq j \leq l}}
\]
**Chromosome encoding**

As shown in Figure 2, \( l \) links among \( n \) learning objects can be mapped on a matrix, where \( \emptyset \) denotes the non-existent link, and the bidirectional connection is considered, i.e., \((N_q, N_n) = (N_n, N_q)\). A chromosome frame is obtained by shifting links row by row to the first row, as shown in Figure 2 and 3. The encoding length for chromosome is the number of links, i.e., \( l \). When encoding the chromosome as solution representation, each individual is encoded by binary code with \( l \) bits according to the chromosome frame, and each bit represents a link. A link is not contained in an individual when this link is encoded as 0. A link is contained in an individual when this link is encoded as 1. An example is shown in Figure 3.

![Figure 2. Matrix for links of learning objects](image)

Chromosome frame: \((N_1, N_2) \cdots (N_1, N_q) \cdots (N_2, N_q) \cdots (N_q, N_n) \cdots\)

Example: \((N_1, N_2), (N_1, N_3), (N_2, N_3), (N_2, N_4), (N_2, N_4), (N_3, N_4), (N_4, N_5)\)

Encoding: \(1 \ 0 \ 1 \ 0 \ 1 \ 0 \ 1\)

Solution: \((N_1, N_2), (N_2, N_3), (N_3, N_4), (N_4, N_5)\)

![Figure 3. Chromosome frame and encoding](image)

**Pre-grouping**

Each link comprises a pre-node and a post-node, i.e., \( L_j = (N_a, N_b) \), and the links are grouped by the same pre-nodes \((N_a)\), as shown in Figure 4.

![Figure 4. Pre-grouping for links](image)

**Initialization**

Based on the link groups, each individual is initialized according to two rules. First, only one of links belonging to \( N_{q-1} \) (start) group is selected randomly and encoded as 1. Second, 0 to 2 of links belonging to \( N_{q+1} \) group can be selected randomly and encoded as 1. An example is shown in Figure 5.

![Figure 5. Initialization](image)
Fitness evaluation

The fitness evaluation has three works of legality check, attribute value computation, and fitness computation.

Legality check

An individual represents a solution; unfortunately, this solution might be invalid due to its meaningless encoding produced by initialization, crossover, and mutation. For instance, an individual encoded as 1110010 represents a solution of \((N_1, N_2), (N_1, N_3), (N_2, N_3), (N_3, N_5)\), but it is invalid. To address this problem, two check mechanisms of node count check and redundancy check are proposed to check the individual’s encoding for the solution legality. Consequently, each individual can be verified as legal or illegal. The legal individuals represent the valid solutions and the illegal individuals represent the invalid solutions.

Node count check

The node count check is to check the count of each node in individual’s encoding by following two rules: First, the count of \(N_{q=1}\) (start) and \(N_{q=n}\) (end) must be 1 only; Second, except \(N_{q=1}\) and \(N_{q=n}\), the count of others must be 0 or 2. If an individual satisfies these two rules, it is a legal and valid solution. For instance, an individual encoded as 0111001 represents a solution of \((N_1, N_3), (N_2, N_3), (N_2, N_4), (N_4, N_5)\), in which the count of \(N_1\) (start) is 1, the count of \(N_2\) is 2, the count of \(N_3\) is 2, the count of \(N_4\) is 2, the count of \(N_5\) (end) is 1 respectively, thereby this individual is a legal and valid solution. Oppositely, an individual is an illegal and invalid solution as it is \((N_1, N_2), (N_1, N_3), (N_2, N_3), (N_3, N_5)\).

Redundancy check

The redundancy check is to check the redundancy link in individual’s encoding by the following rule: The links must be connected one by one from \(N_{q=1}\) (start) to \(N_{q=n}\) (end) without any redundancy link. If an individual satisfies this rule, it is a legal and valid solution. For instance, an individual encoded as 1001001 represents a solution of \((N_1, N_2), (N_2, N_4), (N_4, N_5)\), in which \(N_1\) connects \(N_2\), \(N_2\) connects \(N_4\), and \(N_4\) connects \(N_5\) without any redundancy link, thereby this individual is a legal and valid solution. Oppositely, an individual is an illegal and invalid solution as it is \((N_1, N_2), (N_3, N_4), (N_3, N_5), (N_4, N_3), (N_2, N_7)\).

Attribute value computation

For each legal individual, its attributes’ values are obtained by Equation 2, where \(V_i\) denotes the value of the \(i^{th}\) attribute.

\[
V_i = \begin{cases} \frac{S_i}{C}, & C > 0 \\ 0, & \text{otherwise} \end{cases}
\]

\[
S_i = \sum_{j=1}^{l} X_{ij} \quad \text{if} \quad \text{Encoding}(L_j) = 1 \\
C = \text{Count} (\text{Encoding}(L_j)_{1\leq j\leq l} = 1)
\]

Fitness computation

Here, TOPSIS is enhanced to obtain the individual fitness as follows.

Step 1. Construct an evaluation matrix for legal individuals

Suppose the population has \(p\) legal individuals, an evaluation matrix shown in Figure 6 can be constructed with \(m\) attributes. \(V_{ik}\) denotes the value of the \(i^{th}\) attribute of the \(k^{th}\) legal individual, \(1 \leq k \leq p\).
Step 2. Define the positive-ideal and negative-ideal solution for attributes

Equation 3 defines the positive-ideal solution for the \( i \)-th attribute, and it is denoted by \( V_i^+ \). Equation 4 defines the negative-ideal solution for the \( i \)-th attribute, and it is denoted by \( V_i^- \).

\[
V_i^+ = \begin{cases} 
1, & A_i \in \text{Benefit} \\
0, & A_i \in \text{Cost} 
\end{cases}
\]

(3)

\[
V_i^- = \begin{cases} 
0, & A_i \in \text{Benefit} \\
1, & A_i \in \text{Cost} 
\end{cases}
\]

(4)

Step 3. Compute the multiple dimensions Euclidean distance for legal individuals

Equation 5 computes the distance from the positive-ideal solution for the \( k \)-th legal individual, and it is denoted by \( D_k^+ \). Equation 6 computes the distance from the negative-ideal solution for the \( k \)-th legal individual, and it is denoted by \( D_k^- \).

\[
D_k^+ = \sqrt{\sum_{i=1}^{m} (V_{ki} - V_i^+)^2 \times W_i}
\]

(5)

\[
D_k^- = \sqrt{\sum_{i=1}^{m} (V_{ki} - V_i^-)^2 \times W_i}
\]

(6)

Step 4. Compute the individual fitness

Finally, the individual fitness \( F_k \) is obtained by Equation 7 considering two aspects. The larger \( F_k \), the nearer the \( k \)-th individual is to the optimal solution of scheming learning map under considering multiple weighted attributes with tradeoff objectives.

\[
F_k = \frac{D_k^-}{D_k^+ + D_k^-} + \left( 1 - \frac{D_k^+}{D_k^+ + D_k^-} \right) = \frac{2D_k^-}{D_k^+ + D_k^-}
\]

(7)

Selection

Figure 7 shows the employed roulette wheel selection, and it only is composed of legal individuals with different encodings. The offspring are reproduced according to the individual selection probability (denoted by \( SP_k \)), and it is obtained by individual fitness as shown in Equation 8. Note that, if the population has no legal individuals, the offspring are reproduced randomly from the population.

\[
SP_k = \frac{F_k}{\sum_{k=1}^{p} F_k}
\]

(8)
Crossover

The crossover includes the one-group exchange and fixed crossover probability (denoted by CP) as follows. Two individuals in the population are selected as two parents by CP. One crossover point is selected randomly from the number of link groups. Then, two individuals as offspring are reproduced by exchanging the encoding at the crossover point in two parents. An example is shown in Figure 8.

Mutation

The mutation includes the multi-group reproduction and adaptive mutation probability (denoted by MP) as follows. Each mutation point represents a link group, and it is selected according to the individual mutation probability (denoted by MPk). Then, the encoding at the mutation point is re-encoded according to two rules of the same in initialization. An example is shown in Figure 9.

Regarding the individual mutation probability, Liu (2006) have indicated the fine individual is easy to survive in the offspring since tuning of the mutation probability according to the individual fitness. Moreover, this paper considered
the individual in the early search process should have the higher mutation probability for the larger search space; and in the late search process should have the lower mutation probability for the smaller search space and to survive in the offspring. Hence, this paper tuned \( MP_k \) by not only individual fitness but also elapsed time, as shown in Equation 9. For illegal individuals, a constant \( \alpha (> 1) \) is used to amplify the individual mutation probability, they thereby has the higher mutation probability to expand the search space.

\[
MP_k = \begin{cases} 
\frac{\alpha \times MP}{2} \times \left( 1 - \left( \frac{T}{G} \right)^\beta \right) 
, & \text{for illegal} \\
\frac{\overline{F}_k - \min(F_k)_{1 \leq k \leq p}}{\max(F_k)_{1 \leq k \leq p} - \min(F_k)_{1 \leq k \leq p}} \times MP \times \left( 1 - \left( \frac{T}{G} \right)^\beta \right) 
, & \text{for convergence} \\
\frac{\overline{F}_k}{d_k} + \left( 1 - \frac{d_k}{d_k + D_k} \right) 
, & \text{otherwise}
\end{cases}
\]

For legal individuals, the individual mutation probability is tuned by \( \overline{F}_k \) and \( T \). First, \( \overline{F}_k \) is the opposite direction to the individual fitness \( (F_i) \), \( 0 \leq \overline{F}_k \leq 2 \). Hence, the better individual has the lower mutation probability to narrow the search space and survive in the offspring, and the worse individual has the higher mutation probability to expand the search space. Note that, some computations deal with \( \overline{F}_k \) to be 0–1 in terms of two difference situations. Second, \( T \) denotes elapsed generations, \( G \) denotes total generations, and \( \beta (> 1) \) denotes a decrease rate of individual mutation probability based on \( T \). Hence, the individual has the higher mutation probability for the larger search space in the early search process, and has the lower mutation probability for the smaller search space and to survive in the offspring in the late search process.

Moreover, the population might fall into the premature convergence; however, the adaptive tuning of individual mutation probability by \( T \) can help it carry on search in the early search process. Besides, as the population is convergent in the late search process, the individual has the lower mutation probability to survive in the offspring.

### System implementation

A web-based learning management system based on the proposed approach was developed to directly assist instructors and learners in the educational environment. As shown in Figure 11, the instructors access the developed system through their interface, which includes the concepts management, materials management, and course management; additionally, the learners access the developed system through their interface, which includes the scheming learning map. Such operations are supported by according modules, as shown in Figure 10.
The concepts management module supports instructors to manage the concepts for the courses; that is, the concept relationships, such as prerequisite, dependence, and sequence, are prepared and stored in the learning concepts database. The materials management module supports instructors to manage the materials for the concepts of the courses. First, the learning materials are formal or informal. Second, the learning materials are appeared with various medium forms, for example, PowerPoint, PDF, and Website. As a result, the material sources are prepared and stored in the learning materials database. The course management module supports instructors to manage the learning objects for the concepts of the courses, including set up the initial concept, final concept, and covered concepts. Note that, different learning objects might have the same concept because the learning materials are alternative. The instructors prepare the learning objects by encapsulating the concepts (from the learning concepts database) and materials (from the learning materials database), and store them in the learning objects database.

For the learners, the scheming learning map module supports them to facilitate their customized learning itineraries. After the learning objects of the courses have been prepared by instructors, the model of GA with TOPSIS, i.e., the proposed innovative approach, help learners scheme their learning maps by scheduling the learning objects. Owing to distinct learner characteristics, different learning materials with various forms have distinct effects on learners, such as learning performance (the higher the more favorable, i.e., benefit objective), learning time (the lower the more favorable, i.e., cost objective). The learners have the selection right to prefer their desired learning performance.
and desired learning time according to their personalized requirements; also, the default values are provided by the system. When scheming learning map, the system first loads the learning objects from the learning objects database, and then it schedules the learning objects by the model of GA with TOPSIS, and provides the suggested sequence of learning objects. Notably, select the learning object on the learning map can view its contained materials to learn the concept. After the learners have learned the learning objects, the obtained learning performance (by quizzes) and the taken learning time are recorded by the system and stored in the learning portfolio database. When the learners go back to the same course, the system can facilitate their customized learning itineraries by refereeing the past learning experience of their portfolio.

As a result, having the helps from the developed system with the proposed approach, the workloads can be reduced for instructors and the learning can be smooth for learners. More importantly, the instructors can concentrate on the course design and the learners can concentrate on the concept learning, to increase and promote the quality of teaching and learning.

Simulation experiments

To verify the proposed approach based on enhanced GA with TOPSIS (EGA), several simulation experiments were conducted to compare with two approaches of a genetic algorithm (GA) and a Random method. The random method was usually employed by instructors in the course; the random method was convenient but easy to fall into the inappropriate curriculum sequencing. Additionally, the GA was employed in the similar tasks by previous researches (Chu et al., 2011; Li et al., 2012), and the GA was further enhanced by proposing a forcing legality operation to increase the search efficiency (Chang & Ke, 2013). Regarding the experimental environment, this paper employed Java in implementing these three approaches, which ran on the same machine equipping with 2.5GHz AMD Phenom(tm) II X4 905e CPU and 4GB RAM.

Data sets and parameter settings

The 12 data sets listed in Table 1 are the simulations of scheming learning map, and they were employed as experimental materials. In each simulated data set, the values of attributes of links and the weights of attributes were random, and each attribute was determined randomly as benefit or cost objective.

<table>
<thead>
<tr>
<th>No.</th>
<th>Attributes($m$)</th>
<th>Links($l$)</th>
<th>No.</th>
<th>Attributes($m$)</th>
<th>Links($l$)</th>
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Table 2. Parameter settings

<table>
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<th>Setting</th>
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<td>600 for No.5–8</td>
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<tr>
<td></td>
<td>1000 for No.9–12</td>
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<td>Population size ($p$)</td>
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<td>Mutation probability ($MP$)</td>
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<tr>
<td>$\alpha$</td>
<td>2</td>
</tr>
<tr>
<td>$\beta$</td>
<td>16</td>
</tr>
<tr>
<td>Number of experiment trials</td>
<td>100</td>
</tr>
</tbody>
</table>
Table 2 summaries the parameter settings of EGA, and the generation, population size, crossover probability, and mutation probability of GA were the same as EGA. Besides, the construction of GA was in a general way, including random initialization, roulette wheel selection, single segment crossover (by two crossover points), and multi-points mutation. Note that, the fitness evaluation of GA and Random was the same as EGA in order to compare with EGA. Finally, the number of experiment trials was configured as 100 to obtain the average result for reliability.

Search effectiveness

The effectiveness comparison for EGA, GA and Random is shown in Table 3; significantly EGA is superior to GA and Random in terms of finding the valid solution. As mentioned previously, an individual might be an invalid solution, thereby to find the valid solution is important. In terms of the number of trials to find the valid solution, the search effectiveness of three approaches is analysed as follows. Regarding the Random approach, it only found the valid solution with poor search capability in data sets No.1—2, so its search effectiveness is the worst. Regarding the GA approach, it only found the valid solution with complete search capability in data sets No.1—3 and with poor search capability in data sets No.4—6, so its search effectiveness is the middle. Regarding the EGA approach, it can find the valid solution with complete search capability in data sets No.1—11, and in the data set No.12 its search capability went down slightly, so its search effectiveness is the best.

<table>
<thead>
<tr>
<th>No.</th>
<th>Random</th>
<th>GA</th>
<th>EGA</th>
<th>No.</th>
<th>Random</th>
<th>GA</th>
<th>EGA</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>9%</td>
<td>100%</td>
<td>100%</td>
<td>7</td>
<td>0%</td>
<td>0%</td>
<td>100%</td>
</tr>
<tr>
<td>2</td>
<td>1%</td>
<td>100%</td>
<td>100%</td>
<td>8</td>
<td>0%</td>
<td>0%</td>
<td>100%</td>
</tr>
<tr>
<td>3</td>
<td>0%</td>
<td>100%</td>
<td>100%</td>
<td>9</td>
<td>0%</td>
<td>0%</td>
<td>100%</td>
</tr>
<tr>
<td>4</td>
<td>0%</td>
<td>52%</td>
<td>100%</td>
<td>10</td>
<td>0%</td>
<td>0%</td>
<td>100%</td>
</tr>
<tr>
<td>5</td>
<td>0%</td>
<td>17%</td>
<td>100%</td>
<td>11</td>
<td>0%</td>
<td>0%</td>
<td>100%</td>
</tr>
<tr>
<td>6</td>
<td>0%</td>
<td>2%</td>
<td>100%</td>
<td>12</td>
<td>0%</td>
<td>0%</td>
<td>94%</td>
</tr>
</tbody>
</table>

Solution quality and its search efficiency

Table 4 shows the comparison of solution quality (SQ, i.e., fitness) for EGA, GA and Random, in which the execution time (ET, unit: second) is also reported. Note that, each result is the average from 100 trials, and the fitness of illegal individual (invalid solution) was set to 0. Significantly, EGA has the best solution quality than GA and Random. Regarding the Random approach, over 12 data sets it naturally had the least execution time but had the worst solution quality. Regarding the EGA and GA approach, GA had the less execution time than EGA over 12 data sets that results from EGA has several additional behaviours; however, in terms of the solution quality, only in data sets No. 1–2 GA is similar to EGA, in other data sets No. 3–12 GA is worse than EGA. In short, although additional behaviours of EGA consume the more execution time on searching, they can enhance the search performance.

<table>
<thead>
<tr>
<th>No.</th>
<th>Random SQ</th>
<th>Random ET</th>
<th>GA SQ</th>
<th>GA ET</th>
<th>EGA SQ</th>
<th>EGA ET</th>
</tr>
</thead>
<tbody>
<tr>
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<td>0.0000</td>
<td>1.0594</td>
<td>0.0255</td>
<td>1.0594</td>
<td>0.0591</td>
</tr>
<tr>
<td>2</td>
<td>0.0083</td>
<td>0.0000</td>
<td>1.0577</td>
<td>0.0242</td>
<td>1.0578</td>
<td>0.0754</td>
</tr>
<tr>
<td>3</td>
<td>0.0000</td>
<td>0.0001</td>
<td>1.0872</td>
<td>0.0338</td>
<td>1.1410</td>
<td>0.0971</td>
</tr>
<tr>
<td>4</td>
<td>0.0000</td>
<td>0.0000</td>
<td>0.4969</td>
<td>0.0282</td>
<td>1.1950</td>
<td>0.0955</td>
</tr>
<tr>
<td>5</td>
<td>0.0000</td>
<td>0.0001</td>
<td>0.1660</td>
<td>0.3667</td>
<td>1.1349</td>
<td>1.3195</td>
</tr>
<tr>
<td>6</td>
<td>0.0000</td>
<td>0.0001</td>
<td>0.0196</td>
<td>0.5177</td>
<td>1.1699</td>
<td>1.4894</td>
</tr>
<tr>
<td>7</td>
<td>0.0000</td>
<td>0.0001</td>
<td>0.0000</td>
<td>0.6804</td>
<td>1.1659</td>
<td>1.5552</td>
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<tr>
<td>8</td>
<td>0.0000</td>
<td>0.0000</td>
<td>0.0000</td>
<td>0.7169</td>
<td>1.1834</td>
<td>2.0925</td>
</tr>
<tr>
<td>9</td>
<td>0.0000</td>
<td>0.0000</td>
<td>0.0000</td>
<td>3.1082</td>
<td>1.1370</td>
<td>5.6309</td>
</tr>
<tr>
<td>10</td>
<td>0.0000</td>
<td>0.0000</td>
<td>0.0000</td>
<td>3.2383</td>
<td>1.1100</td>
<td>6.8385</td>
</tr>
<tr>
<td>11</td>
<td>0.0000</td>
<td>0.0001</td>
<td>0.0000</td>
<td>3.9529</td>
<td>1.1232</td>
<td>7.2307</td>
</tr>
<tr>
<td>12</td>
<td>0.0000</td>
<td>0.0001</td>
<td>0.0000</td>
<td>3.6532</td>
<td>1.0690</td>
<td>9.0129</td>
</tr>
</tbody>
</table>
Moreover, Figure 12 depicts the search process of solution quality for EGA and GA, in which each dot in each generation is the average of the solution quality from 100 trials. Significantly, EGA has the better search efficiency based on the solution quality than GA. From the initialization aspect, EGA has the better solution quality at the search entrance in most of data sets. From the search curve of solution quality, EGA has the better search performance in all data sets. From the convergence aspect, EGA achieving the better solution quality is quicker in data sets No. 1–10. Besides, for EGA and GA, their search performance go down from the smaller data set No.1 to the larger data set No. 12, and the decrease of GA is quicker than EGA, even in data sets No. 6–12 the search curve of GA is near to line 0.

Population quality and its search efficiency

Table 5 shows the comparison of population quality for EGA and GA, the population quality is the average of whole individuals’ fitness, and each result is the average from 100 trials. Significantly, EGA has the better population quality than GA over 12 data sets. Moreover, Figure 13 depicts the search process of population quality for EGA and GA, in which each dot in each generation is the average of the population quality from 100 trials. Significantly, EGA has the better search efficiency based on the population quality than GA. From the initialization aspect, EGA has the better population quality at the search entrance in data sets No. 1–3. From the search curve of population quality, EGA has the better search performance in all data sets. From the aspect of the late search process, EGA has the better population quality in all data sets.

<table>
<thead>
<tr>
<th>No.</th>
<th>GA</th>
<th>EGA</th>
<th>No.</th>
<th>GA</th>
<th>EGA</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.1346</td>
<td>0.7520</td>
<td>7</td>
<td>0.0000</td>
<td>0.8827</td>
</tr>
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<td>2</td>
<td>0.0254</td>
<td>0.7894</td>
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<td>0.9141</td>
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<td>0.0000</td>
<td>0.8796</td>
</tr>
<tr>
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<td>0.0000</td>
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<tr>
<td>5</td>
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<td>0.7526</td>
<td>11</td>
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</tr>
<tr>
<td>6</td>
<td>0.0000</td>
<td>0.8212</td>
<td>12</td>
<td>0.0000</td>
<td>0.8759</td>
</tr>
</tbody>
</table>

Because GA fixes the individual mutation probability during the search process, the individual is easy to mutate but the valid solution is difficult to survive. Hence, GA has the poor population quality. On the contrary, EGA tunes the individual mutation probability according to individual fitness and elapsed time. The better individual is easy to survive during the search process; thereby the population quality is better. Especially in the late search process, the population quality is promoted.
Figure 12. Efficiency comparison based on solution quality over 12 data sets

Figure 13. Efficiency comparison based on population quality over 12 data sets
In order to verify whether the developed system is able to provide the reliable helps for instructors and learners, the proposed approach was verified by the above serious of simulation experiments. The results showed that, the proposed approach was significantly excellent based on the search effectiveness, solution quality, and search efficiency; that is, the solution for scheming learning map searched by the proposed approach achieved the excellent quality, and such search process was with excellent efficiency. In other words, the developed system with the proposed approach is able to efficiently scheme the reliable learning maps with high quality for customized learning itineraries. Consequently, the instructors and learners can concentrate on their tasks of course design and concept learning, and needn’t to pay the efforts on scheming learning map.

Conclusions and future work

Personalized learning is an important issue in the field of e-learning. This paper focused attention on scheming learning map, which is not only the NP-hard combination problem but also the tradeoff multiple objectives optimization. Such problem of scheming learning map is, not only impossible for instructors to scheme the fitting learning maps for learners, but also difficult and time-consuming for learners to scheme the fitting learning maps by themselves. Hence, this paper first proposed an innovative approach based on enhanced GA with TOPSIS (EGA), to facilitate the search for the near-optimal solution considering tradeoff multiple objectives. Moreover, a web-based learning management system based on this proposed approach was developed, to help instructors facilitate scheming learning maps for the customized learning itineraries for learners. Consequently, the instructors and learners can pay more attention to their tasks of course design and concept learning, because the workloads can be reduced for instructors and the learning can be smooth for learners by the developed system with the proposed approach.

To verify whether the developed system is able to provide the reliable helps for instructors and learners, the proposed approach, i.e., EGA method, was verified by a serious of simulation experiments. The 12 simulated data sets were employed as experimental materials to compare with two approaches of a genetic algorithm (GA) and a Random method. Each experimental result was the average from 100 trials for reliability. In terms of search effectiveness, EGA is the best among three approaches. In terms of solution quality EGA has the best among three approaches, and in terms of population quality EGA has the better than GA. Moreover, by the insight into the search curve of solution quality and population quality, EGA has the better search efficiency than GA. Finally, in terms of execution time, Random naturally has the least; EGA has the more than GA since it has additional behaviours. To conclude, the proposed EGA significantly is superior to GA and Random in terms of search effectiveness and solution quality; moreover, in terms of search efficiency EGA significantly is superior to GA. Although EGA consumes the more execution time on searching, it can enhance the search performance to obtain a more reliable and higher quality solution for scheming learning map. In other words, the developed system with the proposed approach is able to efficiently scheme the reliable learning maps with high quality for customized learning itineraries. Consequently, the instructors and learner needn’t to pay the efforts on scheming learning map but can concentrate on their tasks.

The contribution of this paper focused on proposing the innovative approach for scheming learning map, and further developing a web-based learning management system based on this proposed approach for teachers and students. From the results of simulation experiments, it was found that the developed system with the proposed approach is able to provide the reliable helps of scheming learning map for teachers and students. Next steps, the experiments regarding the teachers and students using the developed system need to be conducted. It is worth and important to explore the effects on teachers and students by using the developed system. How helpful is the developed system for teachers and students need to be surveyed. Besides, once having the developed system, it is helpful for researchers to discover the learning patterns resulted from students who carries out learning following the schemed learning map.

Acknowledgments

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References


Young Children’s Collaboration on the Computer with Friends and Acquaintances

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ABSTRACT
The processes and patterns of strategies used by children when drawing on the computer with friends and acquaintances were investigated in a case study. The participants were five-and-six-year-old children and the study took place in their home settings. The data collection methods consisted of interviews, observations, audio recordings, video recordings, drawing artifacts, and screen capture. The analysis began with the selection of collaborative episodes, followed by the interpretation of those episodes. The findings revealed a striking contrast between the collaboration of friendship pairs and acquaintance pairs. The friendship pairs exhibited a total number of 23 episodes while the acquaintance pairs engaged in only three episodes. The young children in this study used two main collaborative strategies: (1) establishment of the pretend frame and, (2) coherence and elaboration of pretend frames. The acquaintance pairs applied only the strategy of the establishment of pretend frame while collaborative strategies of friendship pairs showed unique path of progression from the establishment to coherence and elaboration of pretend frames. Established, playful relationships (such as friendships) appear to allow children to productively begin experiencing computer activities.

Keywords
Computer, Collaboration, Young children

Introduction
In recent years, the body of literature on computer use in education has increased substantially. Yet despite the growing body of literature about young children’s computer use, very little is known regarding young children’s interaction in the computer environment. Most of the literature still focuses on older children or adults, and provides insufficient knowledge of young children’s experiences with the computer (Buckingham, 2004; Lomangino, Nicholson, & Sulzby, 1999; Plowman & Stephen, 2005; Stephen & Plowman, 2003; Wang & Ching, 2003). Considering most young children’s computer use involves social and play-related applications (Facer, Furlong, Furlong, & Sutherland, 2003), very few studies are available to substantiate our understanding of young children’s computer experience as play experience (Marsh, 2010; Verenikina, Herrington, Peterson, & Mantei, 2010). The current study is a response to this gap that will enable early childhood professionals to better understand young children’s interactions in a playful computer environment.

Understanding the nature of young children’s collaboration around the computer is essential. First, NAEYC’s (National Association for the Education of Young Children) position statement (Copple & Bredekamp, 2009) reported children’s preference for working with peers around the computer rather than working alone. Secondly, as technology transforms the lives and communications of young children, the patterns of collaboration observed in research studies up to this point may be altered. This study addresses collaborative in two different forms: the collaboration of acquaintances and the collaboration of friends.

Three terms, including play, discourse, and collaboration, require definition for the current study because each phenomenon can be interpreted in numerous ways. First, play in the current study is defined as pretend or make-believe. Our definition of discourse reflects how deeply children’s initial verbal exchanges influence their later collaborative dialogue and is explained further in the findings section, where children’s collaborative dialogue is examined to describe collaborative strategies. The current study defines collaboration as negotiation of shared understanding towards a common goal, as proposed by Crook (1994, 1995, 1998). Negotiation of shared understanding toward a common play goal initiates the collaboration process and then cultivates a distinct collaborative experience.
This study perceives the interplay between pretend play, discourse, and collaboration because collaboration can take place through both actions and dialogues. Several studies have examined specific actions observed in young children around the computer. These collaborative actions included negotiating turns, assisting others by pointing or providing verbal explanations, and collectively discussing and deciding where to click (Brooker & Siraj-Blatchford, 2002; Escobedo, 1992; Heft & Swaminathan, 2002; Lim, 2012; Plowman & Stephen, 2005; Roberts, Djonov, & Torr, 2008; Sandvig, 2006; Shahrimin & Butterworth, 2001; Wang & Ching, 2003). Escobedo’s (1992) study and one recent study of Lim (2012) even found children’s play-related behaviors and language while using computer. All of these studies have indicated that many spontaneous pretend play behaviors occur during the joint computer use of young children, although they did not distinguish acquaintance and friendship relationships.

The literature of collaborative writing has also provided fundamental understanding of the collaborative process. Several studies have identified certain discourse features and patterns in the collaboration process (Chung & Walsh, 2006; Fisher, 1993; Kumpulainen, 1996; Vass, Littleton, Miell, & Jones, 2008). The few available studies pertaining to young children and computers have focused on children’s discourse features in the use of computers and e-games (Hyun & Davis, 2005; Kenner, Ruby, Jessel, Gregory, & Arju, 2008; Roberts et al., 2008). However, none of these studies has scrutinized young friends and acquainted children’s collaboration in terms of how it occurred and evolved as a process in the environment of computer-based play.

Overview of the existing literature

The current study draws on literature related to three areas: friendship, pretend play, and collaboration. Although the literature of these areas may seem unrelated to young children’s computer experiences, it provides insight into the contribution of play language and actions to children’s collaborative experiences in the computer environment.

Friendship and peer culture in play

Previous studies have highlighted the benefit of friendship in collaborative tasks leading to academic success (Azmitia & Montgomery, 1993; Jones, 2002; Kutnick & Kington, 2005; Miell & MacDonald, 2000; Vass, 2002). The work of Corsaro (1985) as well as the work of Howes, Unger, and Matheson (1992) also provide fundamental knowledge of children’s friendships and peer relationships in play. Exploring the world of children’s play, Corsaro (1985) articulated children’s conception of friendship and interpreted children’s use of play as a means of acquiring social knowledge about interacting and communicating with others. Participating in play provides a path for them to construct their own social world through which they learn to deal with conflict, problems, and concerns. Howes and her colleagues also found that young children’s friendships are closely linked to pretend play (Howes et al., 1992). In both studies, Corsaro (1985) and Howes et al. (1992) indicate that children will explicitly mention who their friends are.

Pretend play

For the current study, pretend play opens up an intriguing social arena for collaboration among young children sharing a computer. Garvey (1990) and Vygotsky (1978) have each presented relevant theoretical frameworks of pretend play and collaboration among children. Vygotsky’s (1978) framework established the concept that children’s play contributes to learning. Language serves as a social and cultural tool enabling us to think and learn. As we acquire meaning through this tool, it provides a structure in our minds directly related to our social and cultural experience. Play is a means of advancing development; through play, children create their Zone of Proximal Development (Vygotsky, 1978, p. 86), allowing for new learning. Yeatman and Reifel (1992) also clarified a key principle of play: “Play does not necessarily lead to learning. What play appears to do is to provide a frame in which learning can take place” (p. 154).

Similar to Vygotsky’s (1978) framework, Garvey’s (1990) notion of play was that the use of children’s communicative play language during pretend play creates a shared “as if” world. She identified five types of play language: preparatory talk, explicit directions for pretend, within pretend talk, negation of pretend, and play signals. The first tool, preparatory talk, refers to the language used to initiate play. The second tool is explicit directions for
pretend. For example, a child can say, “Let’s pretend we are running away from the bad guys,” indicating a transformation of joint action. The third tool, enactment talk, occurs when children speak in a manner that befits the characters they are enacting. Negation of pretend happens when children reject their play frame. The last tool, play signaling, refers to communicative signs ranging from high-pitched tones to winks to alert their peers of pretend play mode. Identification of these tools was essential for the data analysis of the current study.

Collaboration in terms of language

The body of collaborative learning literature provides fundamental definition of collaboration. Collaboration is viewed as a means of negotiating a shared conception in the learning process (Crook, 1994, 1995, 1998; Littleton & Häkkinen, 1999; Rogoff, 1990; Roschelle & Teasley, 1993; Scardamalia & Bereiter, 1994, 2006; Vygotsky, 1978). Crook’s (1994, 1995, 1998) notion of “negotiation of shared understanding” resembles the concept of intersubjectivity. Intersubjectivity refers to the process in which individuals take another’s perspective and reach mutual agreement. Crook’s (1994, 1995, 1998) notion of negotiation of shared understanding was applied in the current study in order to identify collaborative episodes involving the collective input of both parties to create an intersubjectivity. The current study focuses on this language exchange process in which children negotiate a shared understanding thus determine their own goals.

A number of studies have presented language use that evidenced both collaboration and dominance in technologically rich environments. For example, dominance behaviors have included directing others, giving evaluative input (Lomangino, et al., 1999) shouting commands and battling for mouse control (Roberts, et al., 2008). In contrast, studies by Chung and Walsh (2006), and Hyun and Davis (2005) have provided evidence of language change in situations where children have gradually become more collaborative. The work of Hyun and Davis (2005) revealed that children’s dialogue evolved from cumulative talk to exploratory talk. Chung and Walsh (2006) expanded on previous understanding by showing the dialogue of kindergartners and first graders shifting from independent to more integrative styles. These two studies informed and led investigators in the current study to look for differences in dialogue as collaboration proceeded.

Other studies also provide contrasting perspectives to examine the language feature within the collaborative process. Fisher’s (1993) observed young children’s talk in computer-supported collaborative writing tasks and classified three language categories: (1) disputational talk, (2) cumulative talk, and, (3) exploratory talk. Even though Fisher (1993) claimed only exploratory talk has educational benefit and indicates knowledge expansion, other studies acknowledge cumulative talk. Other studies provide alternative perspective that substantiated the relationship between repetitive language use and collaboration (Kumpulainen, 1996; Vass et al., 2008). In particular, Vass et al. (2008) described a form of repetitive and elaborative language in which children elaborated on each other’s ideas through free association using chaotic and messy communication. Stemming from the linguistics field, Johnstone’s study (2008) also proposed that in any social encounter, prior discourse is drawn upon and adapted to build a new discourse. We re-use these past communicative strategies, forms, or structures and adopt them in our own new contexts when relevant situations occur, combining them with the play language described in the previous section.

The proposed research question

Previous studies have revealed aspects of collaboration, including peer dynamics, discourse features, and pretend play language. However, the intricate process the emergence, formation, and expansion of young children’s collaboration, and the interconnections between collaboration, friendship, and play remain unexplored. As previously noted, the literature that describes young children’s use of computers is still underdeveloped. Therefore, the current study addressed the following question: How do young children use collaborative strategies while drawing on the computer with friends and acquaintances?

Method

The case study method was adopted for this study because it enabled us to investigate a contemporary phenomenon of collaboration in a real life context, namely, young children’s computer drawing experience. Rather than defining
specific variables and measuring the end product, this case study design reflected an interest in scrutinizing the
dynamics of the process (Merriam, 1998; Yin, 2009). The current case study has drawn on existing theories from the
fields of play and collaborative learning in order to adequately explain children’s collaborative strategies (Merriam,
1998).

Participants

Four pairs of children including two friendship pairs and two acquaintance pairs, all aged five or six, were informally
recruited at the author’s church. Both sets of pairs consisted of one female pair and one male pair. Two short
interviews were conducted to ascertain their friendship and acquaintance status. The following paragraphs briefly
describe the four pairs and the author’s understanding of the children through the church’s primary school program.

The first friendship pair was Grace and Summer, both outgoing Caucasian girls. At the time of the study, Grace was
six and Summer had just turned five. Grace and Summer had been playmates for slightly over three years. Both of
them were unfamiliar with the Kid Pix software. The second friendship pair was Matt and William, both Caucasian
five-year-old boys. Matt and William had been playmates for over two-and-a-half years and frequently sat next to
each other at church. Neither Matt nor William was familiar with the software.

The first acquaintance pair was Peter and Scott, both Caucasian five-year-old boys. Peter and Scott had known each
other for over three years. Scott was familiar with the software but Peter had never used it. The second acquaintance
pair was Abby and Kristin, both six-year-old girls. Kristin is a mixed-race child, part Caucasian and part Filipino.
Abby is a Caucasian girl with Canadian heritage. Both Abby and Kristin had attended several group events but had
never played with each other as a pair. Both of them had previous experiences with similar art software.

Data collection and analysis

Five main collection methods were adopted: observation, audio recording, video recording, collection of drawing
artifacts and screen capture. First, I explained to each pair of children that they would use a computer to draw
together. Each child would have a turn controlling the mouse. Then the observation began. During the observations,
the children’s conversations were tape-recorded. The peer interaction was video recorded. On-screen activity during
the drawing process was recorded using Snow Leopard. The researcher also took notes during the drawing process.
The final drawings they created were saved. The children’s audio-recorded conversations were later transcribed
selectively to include collaborative episodes and segments which I considered to be related to collaborative
strategies.

There were two tutoring sessions for training purposes for all four pairs of children on using the software. The Kid
Pix Deluxe software (Figure 1) contains a variety of icons. Each icon has a specific function. The icons on the left

Figure 1. Screenshot of the Kid Pix Deluxe software
are: background, sticker, animation, sound, undo, drawing, painting tool, paint bucket, mixer tool, rubber stamp, text box, grab tool, and textbox. The bottom selections vary depending on the icon chosen on the left.

All observations took place in the home settings of the participants. Seven observations were conducted including the tutoring sessions for each pair except for the Matt-William pair. For the Matt-William pair, only five observations were conducted due to the unexpected departure of Matt and his family. Each observation lasted approximately 40 to 55 minutes. Data collection took place over a period of four months. The data analysis process transitioned through three phases.

**Phase 1: Identify collaborative episodes and select analytical lens**

Collaborative episodes were identified by the author based on evidence of a shared understanding toward a common goal. Shared understanding was determined by common discourse between participants and based on the video recordings, audio recordings, field notes and screen captures, which were all reviewed repeatedly to capture the verbal and non-verbal strategies in episodes that facilitated collaboration. Transcriptions of the verbal and non-verbal cues that led to collaboration were further examined and annotated.

**Phase 2: Select the framework**

Garvey’s (1990) perspective on play was chosen to provide coding for the data. The following table (Table 1) lists the codes that Garvey (1990) originally proposed and the new modified codes created to adequately present the data collected for the current study.

<table>
<thead>
<tr>
<th>Garvey’s codes</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preparatory talk</td>
<td>“Let’s play.”**</td>
</tr>
<tr>
<td>Explicit direction of pretend</td>
<td></td>
</tr>
<tr>
<td>Transformation of self</td>
<td>“Pretend I am a pirate.”**</td>
</tr>
<tr>
<td>Transformation of other</td>
<td>“Maybe you can be a pirate.”</td>
</tr>
<tr>
<td>Transformation of joint roles</td>
<td>“Let’s be pirates.”**</td>
</tr>
<tr>
<td>Transformation of action for other</td>
<td>“Maybe You can be a pirate and you put the key on the treasure chest.”</td>
</tr>
<tr>
<td>Transformation of nothing to something</td>
<td>“Want a burger?” while holding empty hands.*</td>
</tr>
<tr>
<td>Transformation of environment</td>
<td>“It mixes up everything and the whole world.”</td>
</tr>
<tr>
<td>Transformation of joint actions</td>
<td>“We will die and break ourselves into fishes.”</td>
</tr>
<tr>
<td>Transformation of action for self</td>
<td>“Yes…I am going to get mixed.”</td>
</tr>
<tr>
<td>Transformation of object</td>
<td>“That’s like hot lava.”</td>
</tr>
<tr>
<td>Enactment</td>
<td>“AAH! It is hot! It is burning my feet!” [as if he got burned]</td>
</tr>
<tr>
<td>Transformation of action for onscreen object</td>
<td>“They are touching the ground…get…fire” [point at the mermaid’s tails on the picture]</td>
</tr>
<tr>
<td>Transformation of roles for onscreen object</td>
<td>“They are her little kids.”</td>
</tr>
<tr>
<td>Negation of pretend</td>
<td>“I am going to do some more coloring.” [walked away from the computer]</td>
</tr>
<tr>
<td>Play signal</td>
<td>“Dying! Oh! You fool!” [using a high pitched voice]</td>
</tr>
</tbody>
</table>

*Note.* These three examples are simply to illustrate the category but were not observed in the data.

**Phase 3: Identify and compare the path towards collaboration**

Guided by the clustering and contrasting analysis technique of Miles and Huberman (1994), collaborative episodes identified in the coded data were examined for commonalities and differences. Collaborative episodes showing
commonality or contrast across pairs were identified to indicate the path towards collaboration. Collaborative strategies were labeled based on each observational transcript to reveal whether certain collaborative strategies were used consistently and to show their evolution. Comparisons of strategies could then be made between and among friendship pairs and acquaintance pairs.

**Trustworthiness**

A number of techniques were employed to establish trustworthiness of the data. Trustworthiness was determined by four basic criteria: credibility, transferability, dependability and conformability. The current study adopted four strategies to enhance credibility: prolonged engagement, triangulation, referential adequacy materials, and a reflective journal (Lincoln & Guba, 1985). For example, methodological triangulation was achieved by combining data including the written field notes from the observations, audio and video data collected from the video audio recordings, the screen captures, and the children’s drawing artifacts, which provided verification of the data. The study safeguarded transferability by providing detailed descriptions of children’s verbal and non-verbal exchanges and their interpretation. The audit trail that documented the inquiry process established dependability and confirmability (Lincoln & Guba, 1985).

**Findings**

Most collaborative episodes were carried out in pretend play forms with frequent use of transformations, as described by Garvey (1990). Great contrast and different paths of collaboration were displayed between acquaintance pairs and friendship pairs. The collaborative strategies unfolded naturally and flourished from the tutoring sessions for the friendship pairs. Their pretend language use developed into complex narrative forms for the Matt-William pair. The Grace-Summer friendship pair had six collaborative episodes. The Matt-William friendship pair had 17 episodes. Conversely, the acquaintance pairs gradually shifted from individual exploration to collaboration. Only one collaborative episode occurred for the Peter-Scott acquaintance pair in Session 4 and lasted for only 20 seconds. Two collaborative episodes were identified for the Abby-Kristin acquaintance pair during Sessions 6 and 7. At the beginning, data for both acquaintance pairs revealed limited collaborative episodes and a lack of interest in negotiating toward a shared understanding. The following field notes (Excerpt 1) documented Peter’s unengaged behaviors while Scott was drawing.

**Excerpt 1**

Scott wrote all the names of his family members [while Scott was typing, Peter held the audio recording device in the air, then walked to the video recorder and played with that. Peter then looked from the back of the computer to view the computer screen. He jumped to the table where the computer was set next to the bed and at the end went back to the video. Peter moved underneath the table and pushed the table from underneath] (Feb 5, 2010, Peter Scott session 4).

| Table 2. Accumulated frequencies of transformations and pretend play codes from each observation for the Matt-William pair: The male friendship pair |
|-------------------------------------------------|-----|-----|-----|-----|
| Session                                         | 3   | 4   | 5   | Total |
| Transformation of object                        | 6   | 1   | 5   | 12   |
| Transformation of action for on screen objects  | 23  | 3   | 2   | 28   |
| Transformation of action for self              | 2   | 8   |     | 10   |
| Transformation of other                         | 1   | 4   |   5 |     |
| Transformation of environment                  | 3   |     |     | 3    |
| Enactment talk                                 | 4   | 5   | 9   |
| Negation                                        |     | 1   | 1   |
| Play signal                                     | 4   | 3   | 2   | 9    |
Garvey’s (1990) framework provided categories with which to code the children’s pretend language use. As previously described in the methodology section, two new categories were created in addition to Garvey’s framework to describe the current data: transformation of action for onscreen objects and transformation of roles for onscreen objects. Transformation of action for onscreen objects refers to the use of verbs to portray the actions of objects. The following tables (Table 2, 3, 4, and 5) show the frequencies of play world created from the transformation of action for onscreen objects.

Table 3. Accumulated frequencies of transformations and pretend play codes from each observation for the Grace-Summer pair: The female friendship pair

<table>
<thead>
<tr>
<th>Session</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transformation of object</td>
<td>2</td>
<td>6</td>
<td>14</td>
<td>22</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Transformation of action for on screen objects</td>
<td>9</td>
<td>6</td>
<td>3</td>
<td>10</td>
<td>28</td>
<td></td>
</tr>
<tr>
<td>Transformation of role for onscreen objects</td>
<td>2</td>
<td>2</td>
<td></td>
<td></td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Play signal</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

Table 4. Accumulated frequencies of transformations and pretend play codes from each observation for the Peter-Scott pair: The male acquaintance pair

<table>
<thead>
<tr>
<th>Session</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transformation of object</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Transformation of action for on screen objects</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Play signal</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2</td>
</tr>
</tbody>
</table>

Table 5. Accumulated frequencies of transformations and pretend play codes from each observation for the Abby-Kristin pair: The female acquaintance pair

<table>
<thead>
<tr>
<th>Session</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transformation of object</td>
<td>5</td>
<td>1</td>
<td></td>
<td>6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Transformation of action for onscreen objects</td>
<td></td>
<td>4</td>
<td></td>
<td>4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Transformation of role for onscreen objects</td>
<td></td>
<td>4</td>
<td></td>
<td>4</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The following paragraphs describe two main collaborative strategies: (1) the establishment of pretend frame and (2) coherence and elaboration of the pretend frame. The coherence and elaboration of the pretend frame demonstrates a narrative form of pretend frames. The Matt-William pair’s collaborative strategies progressed from the establishment of the pretend frame to the coherence and elaboration of the pretend frames. Therefore, their experiences will be provided to exemplify both collaborative strategies.

Pretend language use: The establishment of the pretend frame

The pretend language created a common pretend frame through which the children were able to negotiate and build on each other’s ideas. This common strategy serves to establish the pretend frame. Without clearly defined goals from the researcher in their drawing together in front of the computer, all pairs established the pretend frame and determined their goals, thus turning eventually their experiences into collaborative experiences. Pretend language, described by Garvey (1990) as a tool to create the “as if” world, was frequently applied for children in all pairs to confirm their common goals and establish collaboration. Once the peer was invited to join this “as if” world and co-construct this world, collaboration began.

The Matt-William pair illustrates the evolution from pretend language use to coherence and elaboration of pretend frames. The first pretend frame originated with hot lava in tutoring Session 1. Several additional pretend frames subsequently evolved in the following sessions such as fire, burning, and death. The repetitive and elaborative language used illustrates the coherence and evolution of the pretend frames. The identification of a hot lava pretend frame began when Matt used the mixing tool to create a picture. He accompanied his words, “That’s like hot lava,” with actions by blowing toward the onscreen “lava” image. All the pretend frame narratives of the successive collaborative episodes originated from this first session.
Coherence and elaboration of previous pretend frames

The coherence and elaboration of the pretend play frame was grounded in simple pretend language use but transformed into intricate narratives. These collaborative strategies appeared only in the friendship pairs. In one of the tutoring sessions, Matt associated fire with hot lava. Then, when the pirate theme was introduced in Session 3, the idea of burning was elaborated in rich detail. Regardless of the different pretend themes Matt and William established, these episodes revealed continuity of repetitive and elaborate language use around the theme of hot lava, including the action verbs of burning or dying. The following collaborative episode (Excerpt 2) occurred in the middle of Session 3. This episode continued the pretend frame that contained fire and burning, but went further to elaborate in rich detail involving the mermaid. The following transcript reveals that blood, fire and hot lava became interchangeable. The image (Figure 2) also shows that the mermaid could be surrounded by blood, fire or hot lava. Both William and Matt contributed to each other’s ideas.

**Figure 2.** The artifact by Matt to represent the mermaid in fire

**Excerpt 2: The elaboration of hot lava frames on different characters with rich details**

Matt chose another underwater scene, used the paint bucket and picked the color red.
Matt: Oh! Oh!
William: Are you ready? You are going to get dumped. [both of them smiled]
Get blood on the mermaid...Oh! Yeah! Blood all over it!
Matt: Blood in the sky and fall on people’s head. [both of them laughed]
William: Oh! Yeah! That will be great! Awesome. How about blood on their hair?
Matt: They are dying. [using different pitched voice again]
William: Dying! Oh! You fool! [using the same pitched voice -- unrecognizable]
Matt: Look!! Look! They are touching the ground...get ...fire.
William: Feel hot lava. [two of them spoke simultaneously]
Matt: NOOOO!![as if he was getting hurt]
Matt: She is like on the cross. And she is just standing there.

(Dec 31, 2009, Matt-William Session 3)

From the episode above, William and Matt elaborated on each other’s pretend frames and added reasoning to extend and support his peer. The narrative in Session 1 compared to the two tutoring sessions became more complicated by the addition of a variety of characters and different actions by the characters, including the actions that led those characters to death. The reappearance of hot lava and related ideas such as dying or burning in the fire provided coherence. The more complicated narratives demonstrated the strategy of elaboration. Consistent with findings of previous studies including those of Fisher (1993), Johnstone (2008) and others (Kumpulainen, 1996; Vass et al.,
repetitive and elaborative language use occurred in the current study when the children, who had a shared play history, participated in collaborative tasks over time.

Discussion

Three major points guide the discussion: (1) friendship influences collaboration; (2) pretend play serves as a starting point for collaboration; and (3) collaborative strategies progress as collaboration proceeds. Consistent with the findings of Jones (2002), Vass (2002), Azmitia and Montgomery (1993), and Miell & MacDonald (2000), the current study demonstrates the beneficial collaborative outcome that results from friendship. The friendship pair extended the ideas that had been previously established. The co-constructed representation such as hot lava was persistently enriched. The presence of peer represents a strong motivational component of social environment for the other peer to step into the pretend frames to collaborate. The coherence and elaboration of previous pretend frames was possible only if the children desired to immerse themselves in the same pretend frames. The children perceived these collaborative experiences as closely linked together rather than as fragmented pieces.

However, the current study found that it took at least four sessions for the Peter Scott pair to start their first short-lived collaborative episode. Acquaintance pairs had the disadvantage of no shared play experience. Without prior shared play history, the acquaintance pairs were not familiar with each other’s interests, play language, signals, and communication styles. The presence of peer does not automatically facilitate cooperation or collaboration. Consistent with the findings of Chung and Walsh (2006) that children do gradually become more collaborative, the acquaintance pairs demonstrated a gradual change toward a more integrative style, but took a passive approach to entering each other’s experiences at the beginning.

In the current study, evidence of abundant pretend play language leading to collaboration provides connections between Garvey’s (1990) literature on play in young children, Crook’s (1994, 1995, 1998) collaborative learning literature, and the literature related to computer use. This study adopts Crook’s (1994, 1995, 1998) concept of negotiation of shared understanding to identify collaborative episodes. The theoretical framework of play based on Garvey’s (1990) work operates along the same lines as Crook’s definition. The definitions offered from the field of collaborative learning and from the theoretical framework of play both relate to the creation of intersubjectivity (Crook, 1994, 1995, 1998; Roschelle & Teasley, 1993). This study discovered that children establish intersubjectivity through joint conception of pretend frames in order to imagine and play cooperatively and collaboratively. In the current study to account for computer-specific phenomena, two additional categories were needed beyond those Garvey (1990) had previously defined. Furthermore, the findings of this study affirm and extend the previous studies of Escobedo (1992) and Lim (2012). Their studies documented play behaviors exhibited while using the computer. The current study revealed that the coherence of elaboration of pretend frames established intersubjectivity for friendship pairs to collaborate immediately across time.

The progression of collaborative strategies between friendship pairs echoes the discourse features described by Fisher’s (1993) cumulative talk and Johnstone’s (2008) prior discourse and extends the association between repetitive and elaborative language use and collaboration. The current study expands the findings of previous studies by addressing the significance of repetitive and elaborative talk between friends, which the existing literature did not identify as critical to collaborative problem solving.

This progression from pretend language use to the coherence and elaboration of previous frames seems to match very closely with the messy but creative brainstorming process observed in collaborative writing, in which ideas are linked together through free association (Vass et al., 2008). During the negotiation of shared understanding, repetitive and elaborative language use occurred as part of the creative process during the generation of creative ideas. Moreover, this progression from pretend language use to the coherence and elaboration of previous frames presents a similar evolution of language use to that described in the work of Hyun and Davis (2005), which revealed that children’s dialogue evolved from cumulative talk to exploratory talk in the collaborative process. However, the discourse feature shown in the coherence and elaboration of collaborative strategy, which resembles Fisher’s cumulative talk revealed a contradictory perspective. According to Fisher’s (1993) findings, the exploratory talk, in which a joint conclusion results from challenging the ideas of one’s partner, is considered the type of talk most beneficial for collaborative inquiry, rather than cumulative talk. Given that pretend play is an effective starting point
for young children’s collaboration, its significance in collaborative dialogues cannot be over-emphasized especially for young children, for whom pretend language use is so dominant.

The progression of collaborative strategies can also be examined in light of Vygotsky’s (1978) notion of ZPD (zone of proximal development). Building from the use of pretend language to a more complex level of the pretend frame revealed that the friendship pairs scaffolded each other in this collaborative process to reach their ZPD. The unengaged behaviors in the Peter-Scott pair can also be examined in light of Vygotsky’s scaffolding concept. Among these four pairs, the Peter-Scott pair theoretically should have been the optimum pair, in that one owned expert knowledge and the other had a rather limited experience of the software. Because of this knowledge gap between children, this pair represented an abundant scaffolding opportunity, creating the ZPD, as Vygostky (1978, p. 86) would call it. However, Scott never scaffolded Peter.

Finally, the current study found rare instances of language that served to establish social status. This is incongruent with several previous studies. Those studies documented that either in play or in collaborative computer-related activities children established hierarchy, and children with higher social status dominated and exerted power over children with lower social status (Corsaro, 1985; Lomangino, Nicholson, & Sulzby, 1999; Roberts, Djonov, & Torr, 2008). In this study, children did not use language such as imperatives to dominate the relationship, as described by Corsaro (1985). Rather, they persuaded their partners while acting as scaffolders. Both Matt and William crafted the narrative to create collaborative opportunities for their partners. Therefore, in this study, using language to exert power appeared in the more subtle form of persuasion rather than as an expression of domination.

**Practical implications**

The current study found that it took at least six sessions for some of the children to start their first short-lived collaborative episode. Their lack of desire to participate in each other’s experience implied that some children might not have been well matched for collaboration. This highlights the social aspect of collaboration, which teachers need to take into consideration when pairing children up for a collaborative task. Moreover, the experience of the acquaintance pairs poses questions for the participatory role of the teacher and the degree of facilitation required by the teacher to assist children in working together on a joint task. Teachers need to understand that it might take a considerable amount of time for children with no play history to actively collaborate, and they can help build relationship prior to pairing children up for collaborative projects.

While some Early Childhood Education (ECE) teachers may believe that young children using computers should be left alone to freely explore the software, this places teachers in a reactive and non-participatory role without any consideration of the social factors of the children involved. When there is an un-established friendship status between young children, teachers might need to take a proactive and facilitative role to cultivate the social aspect of children’s collaborative computer experiences.

As discussed previously, pretend play serves as the starting point of collaboration. Teachers can model pretend language to facilitate collaboration. When teachers observe children’s pretend language, teachers can then extend that pretend language into a more sophisticated form. The two collaborative strategies discussed in findings closely matched with Fisher’s (1993) concept of cumulative talk and the increasing complexity of brainstorming ideas in the collaborative writing process (Vass et al., 2008). The practical implication of this particular finding is that while teachers may regard exploratory talk as having educational value, they should also recognize that repetitive talk and elaborative talk can lead to collaboration, though this strategy has been undervalued in the exiting literature.

**Limitations**

The limitations of the current study involve two aspects: scale, and participants. While analysis of the current study has revealed the nature, type, and progression of collaborative strategies for four pairs of children, including friendship pairs and acquaintance pairs, this study is still considered a small-scale study exploring the phenomenon of the collaboration of young children engaged with the computer. Therefore, the findings are not generalizable to a large population. With regard to the participants, it needs to be restated that the Matt-William pair had only five sessions in total instead of seven sessions as did the other three pairs due to Matt’s family’s sudden move; in other
words even more collaboration may have been possible. Out of these five sessions, the Matt-William pair showed greatest variety of collaborative strategies in compared to the other three pairs, notwithstanding their small number of sessions.

Conclusion

The analysis of the findings for the current study affirms, revises, and extends the existing literature. The complexity and variety of collaborative strategies from friendship pairs, especially with the action game, affirm the benefit of friendship in collaboration. However, one finding of the current study regarding repetitive and elaborative language differs from the perspective of the existing literature. While previous studies disprove its benefit for collaborative problem solving, the current study has shown that it does contribute to creative collaboration in a way similar to the collaborative writing process. Finally, the findings of the current study extend the existing literature in three areas. First, the current study identifies four levels of collaborative strategies through the pretend play perspective and further defines a unique path of progression for these collaborative strategies. Second, the addition of two new codes including transformation of action for onscreen objects and transformation of role for onscreen objects extends Garvey’s (1990) framework regarding pretend play language to collaborative interaction in computer environments. Third, the finding of pretend play as the starting point for young children’s collaboration reveals the relevance of pretend language and collaboration. The current study bridges the literature of play and collaborative learning and expands our limited existing theoretical knowledge of both play and collaborative learning.

References


Social Constructivist Approach to Web-Based EFL Learning: Collaboration, Motivation, and Perception on the Use of Google Docs

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ABSTRACT

This study reports on the differences in motivation, vocabulary gain, and perceptions on using or the Google Docs between individual and collaborative learning at a tertiary level. Two classes of English-as-a-Foreign Language (EFL) students were recruited and each class was randomly assigned into one of the two groups - individuals or collaborators. The results of the study are in line with those of previous studies in that the collaborators performed better than the individuals regarding vocabulary gain. The former was more likely than the latter to be motivated to acquire knowledge and to perceive the learning experience more positively. However, the results of this study suggest that, like many other Web 2.0 applications in support of peer scaffolding and knowledge co-construction, Google Docs plays a pivotal role in enhancing students’ motivation and involvement.

Keywords

Web 2.0, Motivation, Web-based learning, English-as-a-foreign language

Introduction

Social influence is considered to have a significant impact on academic success (Schunk, 1999; Riese, Samara, & Lillejord, 2012). It postulates that if students are more able to maintain their social relationships with others in school, they are likely to perform better academically than those who are not. In second or foreign language (L2/FL) learning, there has been great interest among L2/FL researchers and educators in how learners interact with one another for knowledge co-construction or the negotiation of meaning in traditional face-to-face settings in order to enhance linguistic knowledge in the target language, e.g., Foster and Ohta (2005), and Dobao (2012; 2014).

Thanks to emerging technology or computer use for daily communication, e.g., emails and chats, socialization has inevitably become part of our everyday lives. In particular, the Internet has been one of the most important resources for strengthening students’ learning experiences at the tertiary level (Lee & Tsai, 2011; Liu, Lan, & Ho, 2014); it potentially provides genuine communication to foster autonomous learning (McLoughlin & Lee, 2010). Such meaningful communication via the Internet for educational purposes has been widely researched in recent years, as it is believed that it engenders students’ meaningful learning experiences and improves their motivation and engagement (Chu & Kennedy, 2011; Hwang, Wang, & Sharples, 2007; Cheng & Chau, 2013; Winke & Goertler, 2008; Cho & Kim, 2013; Razon, Turner, Johnson, Arsal, & Tenenbaum, 2012; Lan, 2014; Lee & Tsai, 2011; Cho & Jonassen, 2009). However, the relationship between motivation and collaborative learning in a specific context has remained under-explored in the conventional classroom setting (Järvelä, Volet, & Järvenoja, 2010) or in the web-based environment. Taken together, in this study, the main focus is on the impact of online text-based collaboration outside the classroom on the constructs (e.g., motivation and vocabulary gain) by examining the quantitative data of the questionnaire survey and the Google Docs log files.

Socially web-based learning in FL

Socially web-based tools have been increasingly adopted for L2 or FL learning. As such, online text chats are being utilized for examining modified interaction between less and more capable interlocutors in order for L2/FL development to occur. During a problem-solving task, a learner’s non-target linguistic items that often cause misunderstanding or communication difficulty need to be corrected through employing a clarification request or comprehension check. Such corrected items provide the learner with linguistic input that learner may then use it to generate his/her output; it potentially pushes the learners’ production (Yilmaz, 2011). In Collentine and Collentine’s...
(2013) study by adopting a corpus approach to examining learners’ complex syntactic structures in Spanish in a SCMC setting, their results show that learners are likely to produce the target sentences (nominal clauses) to reply to their expert interlocutors. Their findings suggest that interaction taking place in SCMC can promote learners’ syntactic knowledge in the target language. Supportive of negotiated interaction that leads to L2/FL development, Smith and Renaud (2013) have put it forward that due to network delay time that affords learners to have more time to process input and monitor their output. In their study, they employed eye-tracking technology to explore L2 learners’ attention paid to lexical and grammatical features of the corrective feedback provided by their instructors during text chats. The way in which learners fixated on the target items had a great impact on their linguistic knowledge; learners who were likely to notice the linguistic items tended to acquire them. The results of their study suggest that the amount of eye fixation time significantly associated with the posttest scores (e.g., learners were asked to correct ungrammatical sentences), whereby those fixedated items were more likely to be recalled by the participants compared to those which were not fixated.

Likewise, some other relevant studies provided positive results which web-based tools enhance particular knowledge attainment. Aydin and Yildiz (2014) examined whether their participants working collaboratively on writing tasks could improve the accuracy of grammatical structures in the Wikis. Due to the nature of asynchronous text chats under investigation in that study, learners were allowed to look through their chats at their disposal and more importantly to notice their linguistic errors or erroneous production; this may help them focus their attention on the linguistic aspects and might in turn improve their grammatical knowledge. In the same vein, Polat, Mancilla, and Mahalingappa (2013) examined whether L2 vocabulary attainment related to the asynchronous discussions among learners and their results reveal that those who participated in the discussion gained vocabulary knowledge significantly better than those who did not. Hence, it assumes that error correction occurs more frequently in the collaborators group than that in the individuals group as the former who attempt to understand others’ messages are likely to correct or clarify meaning of the lexical errors in the production. This then will improve learners’ lexical knowledge in the language.

Inspired by some other research studies investigating whether social mediation influences L2/FL knowledge through SCMC, the vocabulary knowledge gained by the individual learners and collaborators was examined in this present study. The vocabulary gain as a type of the knowledge in L2/FL refers to the outcome of learners’ performance to be measured by the recall test (Kirschner, Paas, & Kirschner, 2009), based on the L2/FL vocabulary research studies (Türk & Ergüç, 2014; Liu, Lan, & Jenkins, 2014). As a lexical recognition knowledge test, it measured receptive vocabulary knowledge in terms of whether learners remembered or recognized the words from the reading passages which were adopted in this current investigation. As such, recall tests conducted after experiments or treatments are often adopted to determine the impact of SCM collaboration on knowledge attainment, see examples of these in Polat, et al. (2013) and Smith and Renaud (2013).

**Socially web-based learning and social constructivism**

Socially web-based learning underlines the notion of that “knowledge should be constructed from multiple resources of the student-led collaborative learning environment” (Gale, 2003, cited in Razon et al., 2012), meaning that knowledge is co-constructed by the individuals in a group through interacting with others; hence, the collaboration is highly emphasised in order to complete a given group project or task. Initially, collaboration denotes the concept “social constructivism” (Vygotsky, 1978), collaborative interaction between interlocutors to create meaning in a dialogue as a goal-directed activity between a speaker and a hearer (Lantolf & Pavlenko, 1995). The influence of collaboration on learning has highlighted that learning is assumed to be a socially mediated process (Zimmerman, 1989; Schunk, 1999; Pintrich, 2000). However, such a process appears multi-dimensional, involving a person's cognitive, motivational, and social aspects (Pintrich, 2000). In L2/FL, collaborative learning contributes to language knowledge (Storch, 2005; Kim, 2008) by means of developing critical thinking and problem-solving skills (Nyikos & Hashimoto, 1997), as it involves the affective feelings by group members showing their interest and encouragement during negotiated interaction (Foster & Ohta, 2005).

Some previous research has investigated writing processes and perceptions of Google Docs and suggests that learners support each other in terms of linguistic knowledge and strategy use leading to a positive perception of collaboration in the web-based environment (Kessler, Bikowski, & Boggs, 2012). Those results have been corroborated by other studies. For example, Kennedy and Miceli (2013) reported on that those working with others
tended to have more positive perceptions and greater appreciation of wikis, as they were more likely to feel connected to others or to feel a sense of community.

In addition to the social aspect, an underlying construct of motivation is often observed in L2/FL learning, referring to an individual’s effort and desire to accomplish the goal in the target language, as well as favourable attitudes toward learning the language (Gardner, 1985). It is the driving force of the individual to initiate learning the target language and sustain the long, tedious learning process (Dörnyei, 1998). It implies that a motivated learner strives to learn the language in order to achieve a personal goal, such as to get a better grade or to get praise from parents, as considered to be an important factor that influences the achievement of L2/FL. To date, it has been examined in relation to whether use of the social web tools enables to enhance learners’ motivation and interest in acquiring the language (Yang, 2011) or course knowledge (Razon et al., 2012). In Warschaucer’s (1996) study, compared with those in a traditional setting, learners not only have positive attitudes towards online discussions with their peers but also are able to produce more complex lexical items or sentences than those in a traditional setting due to feeling less stressed in an online environment. Supporting Warschaucer’s (1996) claims, Lee and Tsai (2011) found that those students who were more interested in Internet-based learning showed a higher level of perceived self-regulated ability than those who were not.

Together with some other relevant constructs affecting skill performance, it assumes that attitudes towards technological applications has an important impact on subsequent behaviour (e.g., investing time in given activities), that is, the amount of effort learners put into learning by sharing each other’s annotations relates to the usage or evaluation of a given technology and reading achievement (Hwang et al., 2007). Such a claim is further supported by Ma and Kelly (2006) who examined a number of user actions by measuring the time spent on the program, given tasks, and so on. They found that the amount of time use on the program, words reviewed in the system, and scores obtained for the exercises, are associated with learning outcomes and learner evaluation. The amount of time spent on the Internet may have an impact on the learning experience as Lee and Tsai (2011) argue that students who spent more time on the Internet were likely to have a more positive perception of the aspects of self-regulated and collaborative learning in the environment.

This can be explained in that social interaction allows a group of students to understand or see from the new perspective of others, meaning that they are likely to engage in deep processing in learning (Tsai & Tsai, 2013) and to discover the ideas of others (Storch, 2005). This is due largely to the collaborative effort required to reduce the cognitive load given the limited capacity of the working memory to process information; in turn, group members are more capable of constructing higher quality schemata in their long-term memory and of supporting a positive effect on the in-depth learning of complex tasks (Kirschner et al., 2009). However, most current empirical studies have focused on L2 learning in general without looking at specific contexts. In addition, previous studies have mostly investigated the perceptions of students’ motivation or engagement, but have overlooked their learning behaviour in the web-based environment. To sum up, little is known about the interrelationship between the factors that affect students’ learning on the web. Hence, there is an emerging need to provide a better understanding of such related constructs in a specific learning context. That is, this study aims to investigate the impact of social collaboration on vocabulary gain and on the constructs of motivation and perception of the web-based learning environment by adopting sociocultural and cognitive theories.

Method

Participants

This study involved 65 EFL students recruited from the Department of Tourism and Transportation at the chosen university, including 32 (49%) male and 33 (51%) female students. All participants were regarded as being intermediate level students; their proficiency level in English was determined by the diagnostic placement test administered before they attended the compulsory English classes taking place on campus. Two intact classes of sophomore students were randomly assigned into the collaborators group \(N = 34\) and the individuals group \(N = 31\).
### Instruments

#### Vocabulary pre-/posttests

The vocabulary pretest and posttest were an identical version of English vocabulary test instrument, see Appendix A; they were adopted to assess the participants’ vocabulary knowledge prior to the experiment and the vocabulary gain after the experiment. The vocabulary test measured the participants’ receptive vocabulary knowledge. It consisted of 40 target vocabulary words chosen from the learning materials, note that 6 or 8 vocabulary words were taken from each reading article, a total of six articles in the learning materials (see the discussion in the Reading Tasks section). The vocabulary test instrument was categorised into five dimensions: (1) 5 items for a matching test, in which words were provided to correspond to their similar meanings or words in English; (2) 5 items for a cloze test for a less-than-100 words long article; (3) 8 items that required matching up their similar meanings in English; (4) 12 items for a matching test with words’ meanings in Chinese; and (5) 10 items for a cloze test, where students had to supply the meaning in Chinese of the target words underlined in the short reading text.

#### A paper-pencil questionnaire survey

The design of the questionnaire survey was partially adapted from Pintrich and de Groot (1990), Zimmerman (1989), Gardner (1985) and Liu, Lan, and Ho (2014), including two main sections: (1) questions relating to the demographic information of the participants, e.g., age, gender, and major; and (2) statements regarding two constructs of the perception of motivation and of using Google Docs. All items were rated on a five-point Likert scale, 1 = “strongly disagree,” 5 = “strongly agree,” with higher scores implying more positive perceptions. In the first construct, a total of 20 closed-ended items in Appendix B were divided into three sub-components: (1) 11 items for motivational beliefs, (2) 5 items for self-efficacy, and (3) 4 items for test anxiety. As a result, all the items of this study had a good internal consistency as shown by the Cronbach’s Alpha coefficient value of .906.

The other construct regarding perception of learning on Google Docs, based on Davis (1989) and Liu, Lan, and Ho (2014), consisted of four sub-components with a total of 16 closed-ended items rated on a five-point Likert scale as stated in the preceding paragraph. Each sub-component subsumed 4 closed-ended items as shown in Appendix B. The first sub-component dealt with the effects of Google Docs on learning, the second was related to attitude towards learning on Google Docs, the third was concerned with ease of use, and the last was related to the extent to which the participants were engaged in the learning activities on Google Docs or whether they liked or disliked the learning tasks. All the closed-ended items were computed to test the internal consistency, and this resulted in a substantial value of Cronbach’s Alpha, which was .941.

#### Reading tasks

There were six articles as the reading tasks made available on Google Docs over the eight-week out-of-class period. They were mainly short reading articles adapted from the participants’ textbook (Stempleski, Morgan, & Douglas, 2011) and online resources. Each reading article was less than 300 words in length with accompanying three or five comprehension questions. There were 20 questions in total as shown in Table 1. For instance, the second reading article, “Eco-tourism” talking about types of activities that people undertake during an eco-tour, consisted of four questions, e.g., “What does this article talk about?”

<table>
<thead>
<tr>
<th>Topics</th>
<th>Contents</th>
<th>Post-reading questions</th>
</tr>
</thead>
</table>
| Cities      | Relating to the cities that people live in and this helps students to get familiar with English vocabulary words, such as shops and places. | • What is the main idea of this article?  
• What are the advantages and disadvantages living in cities?  
• Can you describe the city where you live? Do you like it? Why? |
| Eco-tourism | Describing what the eco-tourism is about and what types of activities people undertake | • What does this article talk about?  
• Is it a good idea to take an eco-tour?  
• What types of activities does this article mention? |
| Personality | Regarding some positive and negative personalities of individuals, such as generous and selfish. | • Please describe types of characters do people have in this article.  
• What are positive and negative traits? Why?  
• What types of personalities are you? |
|---|---|---|
| Movies | Talking about different movie types, including horror and action ones. | • How many types of movies are mentioned in this short text?  
• What does a remake movie mean?  
• What kinds of movies do you prefer to watch? Why? |
| A memorandum | Concerning a message in relation to the HR policy that was sent to all supervisors of the company. | • What does the memorandum intend to mean?  
• According to this text, when will the new HR policy become effective?  
• In this article, what employment benefits will new employees have? |
| Fast food | Talking about the impact of fast food on the health of people. | • What does this article talk about?  
• What are the advantages and disadvantages having fast food?  
• According to this article, what are the most health issues when people have fast food?  
• Do you like fast food? Why? |

**Google Docs and log data**

Google Docs provides a number of tools similar to those in the Microsoft Office suite including spreadsheets, word processing, and presentations etc., allowing multiple users to edit or to work on the same document at the same time or at different times (Thomas, 2011), note that the participants of the present research were only allowed to use the word processor on Google Docs to complete the learning tasks. Revisions to a document are kept in the system making it possible for users to retrieve earlier versions; such an application is deemed to be useful for collaborative work or knowledge co-construction and for the enhancement of engagement among learners (Dekeyser & Watson, 2006; Thomas, 2011).

An example of the log files that recorded the revised texts done by the participants is illustrated in Figure 1, the top, showing the drop-down menu in Chinese, including “File,” “Edit,” “Format,” and etc. In the top right area, there are two main tools: the one on the left indicates an annotation tool while the one on the right allows users to share the same document. In this current study, the function of the sharing tool was activated in the group of collaborators whereas such a tool was not activated in the group of individuals.

![Figure 1. An example of the log file on Google Docs](image)

In the above figure, the central area showed the students’ revised work, which contained answers to the comprehension questions of the reading text.
Log data containing the text corpus regarding lexical items used by the collaborators and the individuals were further analysed. Three types of lexical errors identified in this current research were based on the classifications of Lyster (1998) and McDonough and Sunitham (2009). Type 1 referred to words with incorrect spellings “stomachach” and “supplier” in italics as shown in Table 2. Type 2 errors were misused words, for example, a learner was confused of the word “confirm” and “conform.” The last type was that expressions relating to the target words were not appropriate. Note that messages written in Chinese were eliminated.

Table 2. Types of lexical errors

<table>
<thead>
<tr>
<th>Types of errors</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type 1</td>
<td>“… people got stomachach because they eat too much junk food”</td>
</tr>
<tr>
<td></td>
<td>“[McDonalds] … a food supplier …”</td>
</tr>
<tr>
<td>Type 2</td>
<td>“I’ll feel scary if I travel by myself.”</td>
</tr>
<tr>
<td></td>
<td>“… the manager conforms the message that …”</td>
</tr>
<tr>
<td>Type 3</td>
<td>“Probation periods will be observed the suitability and attitude…”</td>
</tr>
<tr>
<td></td>
<td>“All the preservative used in our food, they reduce our resistance”</td>
</tr>
</tbody>
</table>

Repair initiation occurs when a learner’s production contains lexical or grammatical errors that hamper understanding of the intended meaning, where the interlocutors initiate negotiation by using comprehension or/and clarification checks. In Example 1, S25 was confused about “impulsive” and “compulsive” when she tried to describe her friend’s personality (in Task 3), where S21 not only employed a strategy (asking for help) but also gave a comment on the turn of S25. Finally, S24 provided the correct form “impulsive” to the misused word “compulsive” though she was unsure of the word usage as used a dictionary to help her check the word.

<Example 1>
S25: my best friend…when she goes shopping… because cannot control herself. She just buys a lot of things she doesn’t need, she is some kind compulsive
S21: … what’s compulsive? I think she’s too crazy.
S24: maybe… impulsive? Let me check my dictionary.
S24: it (dictionary) said… should be impulsive, do you guys agree?
S25: I guess you’re right.

Research questions

• Are there any significant differences in the variables of vocabulary gain, motivation, and perception of web-based collaborative learning between the collaborators and the individuals?
• Do the collaborators have higher levels of engagement and participation in the web-based environment than do the individuals?

Procedure

The 8-week experiment was conducted to examine the effects of collaboration on the participants’ vocabulary gain by the collaborators and the individuals working in the web-based environment. In accordance with the data collection procedure, two classes were randomly assigned into the experimental (collaborators) and the control (individuals) groups. Note that the introductory sessions for two groups were arranged separately at the university computer lab. The vocabulary pretest was then administered to the participants, which they took about 20 minutes to complete. Following this, they were instructed to register for Google Docs accounts; the collaborators, who were sub-divided into ten small groups of 3 or 5, were allowed to edit and share the same documents, whereas the individuals worked on their own to edit or revise a given document. The learning materials were designed to be supplementary to the compulsory English class where the students and the researcher met once a week, two hours each time in a face-to-face classroom setting. In order to encourage the participants to accomplish the given tasks, they were informed that the completion of the work was worth 5% of their total grade for this course. It is worth noting that the teaching methods and materials used were identical for both groups of students in class.
There were six different learning materials in this experiment. However, in order not to overwhelm the participants with six learning activities given altogether at the same time, one learning material was uploaded onto Google Docs every nine or ten days. The vocabulary posttest and the questionnaire survey were administered to the groups in the last week and collected in the presence of the first author of this paper. The log data that recorded the changes to documents made by the participants were gathered at the end of the experiment and computed further for statistical analysis.

Results

Vocabulary gain

The first research question is to determine the difference between the groups in terms of the variables of vocabulary gains, levels of motivation, and perception of web-based collaborative learning. The vocabulary pre-/posttests were administered to the participants prior to and after the experiment. To determine the impact of collaborative learning on vocabulary knowledge, the independent samples t-tests was first used to test the difference in the mean scores of the vocabulary pretest between the groups. Results shown in Table 3 indicate that the participants’ vocabulary knowledge did not differ significantly between the collaborators (M = 21.94, SD = 7.64) and the individuals (M = 22.00, SD = 6.67, t(53) = .03, p > .05, r = .05). The independent samples t-test was further used to test the difference in the mean score of the vocabulary posttest between the groups. Although the collaborators had a higher mean score (M = 29.79) than did the individuals (M = 27.29), the mean difference was non-significant between the collaborators (SD = 7.37) and the individuals (SD = 7.92, t(62) = 1.26, p > .05, r = .16).

Table 3. Results of the independent samples t-tests for vocabulary gain between the groups

<table>
<thead>
<tr>
<th></th>
<th>Collaborators</th>
<th>Individuals</th>
<th>t</th>
<th>p</th>
<th>Effect size</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M</td>
<td>SD</td>
<td>M</td>
<td>SD</td>
<td>(r)</td>
</tr>
<tr>
<td>Pretest</td>
<td>21.94</td>
<td>7.64</td>
<td>22.00</td>
<td>6.67</td>
<td>.03</td>
</tr>
<tr>
<td>Posttest</td>
<td>29.79</td>
<td>7.37</td>
<td>27.29</td>
<td>7.92</td>
<td>.126</td>
</tr>
</tbody>
</table>

The above statistical results show that the difference in the pretest between the collaborators and the individuals was not significantly associated, which means that both groups’ vocabulary knowledge was similar before they participated in the experiment. In the posttest, the two groups’ vocabulary knowledge did not differ significantly (p > .05). Such results are in line with those found by Nassaji and Tian (2010) and Storch (2005). However, to have examined the difference in the mean scores of the pretest and the posttests within a group, the results suggest the mean score of each group reached a significance level (p < .00); the collaborators had gained more vocabulary knowledge than had the individuals as the mean difference 7.85 of the former group was greater than the mean difference 5.29 of the latter group.

Furthermore, the frequencies of lexical errors and repair initiations were calculated and compared between the collaborators and the individuals group. In Table 4, the former resulted in more lexical errors (N = 78) and more instances of repair initiation (N = 42). The frequency of repair initiations differed significantly (p < .05) between the collaborators (N = 42, 54%) and the individuals (N = 1, 5.9%). Of these, the collaborators group had more repair instances of Type 2 (N = 37) than those of Type 1 or 3, while Type 3 repair had resulted in zero repair instance. The individuals had only one repair instance of Type 1. The findings indicate a tendency that the collaborators were more likely to repair the lexical errors than were the individuals.

Table 4. Frequency of lexical errors and repair initiations

<table>
<thead>
<tr>
<th></th>
<th>Collaborators</th>
<th>Individuals</th>
<th>Repair initiation</th>
<th>Total errors</th>
<th>Repair initiation</th>
<th>Total errors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type 1</td>
<td>19 (79%)</td>
<td>24 (100%)</td>
<td>1 (25%)</td>
<td>4 (100%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Type 2</td>
<td>23 (62%)</td>
<td>37 (100%)</td>
<td>0 (0%)</td>
<td>6 (100%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Type 3</td>
<td>0 / 0 (%)</td>
<td>17 (100%)</td>
<td>0 (0%)</td>
<td>7 (100%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>42 / (54%)</td>
<td>78 (100%)</td>
<td>1 (5.9%)</td>
<td>17 (100%)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Motivation

The construct of motivation was measured by a questionnaire survey which contained 20 closed-ended questions rated on a 5-point Likert scale, with “1” indicating “strongly disagree” and “5” indicating “strongly agree.” In Table 5, the mean difference in the construct between the collaborators (M = 3.76, SD = 9.35) and the individuals (M = 3.37, SD = 7.12) reached a significance level [t(53) = 2.17, p < .05] with a small effect size (r = .28). The construct was sub-divided into three sub-components, namely, motivational beliefs, self-efficacy, and test anxiety. First, the collaborators had a higher level of motivational beliefs than did the individuals as shown by their respective mean scores of 3.69 and 3.36. The mean difference shown in Table 5 suggest that the level of motivational beliefs differed significantly between the groups [collaborators, SD = 5.36, individuals, SD = 4.54, t(53) = 2.68, p < .01] with a medium effect size (r = .35).

Similar to the first sub-component, the collaborators had a higher level of self-efficacy than did the individuals. The level of self-efficacy was significantly different between the groups, whereas the collaborators (M = 3.88, SD = 2.67) perceived themselves as more capable than did the individuals (M = 3.45, SD = 2.73, t(53) = 2.90, p < .005). This accounted for a medium effect size (r = .37). Finally, those who worked collaboratively had lower test anxiety (M = 2.94) than did those who worked individually (M = 3.03). The collaborators had a slightly lower degree of test anxiety than did the individuals, as the difference was non-significant between the two groups (p > .05). Nonetheless, the small effect size (r = .13) explains 1% of the total variance (Field, 2009).

<p>| Table 5. Results of the independent samples t-tests for the construct of motivation and its sub-components |
|------------------------------------------|----------|----------|-----------|---------|------------|</p>
<table>
<thead>
<tr>
<th></th>
<th>Collaborators</th>
<th>Individuals</th>
<th>t</th>
<th>p</th>
<th>Effect Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Motivation</td>
<td>M = 3.76</td>
<td>SD = 9.35</td>
<td>M = 3.37</td>
<td>SD = 7.12</td>
<td>2.17</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>.042*</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>.28</td>
</tr>
<tr>
<td>Motivational beliefs</td>
<td>M = 3.69</td>
<td>SD = 5.36</td>
<td>M = 3.36</td>
<td>SD = 4.54</td>
<td>2.68</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>.010**</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>.35</td>
</tr>
<tr>
<td>Self-efficacy</td>
<td>M = 3.88</td>
<td>SD = 2.67</td>
<td>M = 3.45</td>
<td>SD = 2.73</td>
<td>2.90</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>.005**</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>.37</td>
</tr>
<tr>
<td>Test Anxiety</td>
<td>M = 2.94</td>
<td>SD = 2.20</td>
<td>M = 3.03</td>
<td>SD = 3.34</td>
<td>- .43</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>.668</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>.13</td>
</tr>
</tbody>
</table>

Note. *p < .05. **p < .01. ***p < .001.

Web-based learning

The construct of the perception towards Google Docs learning was first tested to obtain the mean scores of the collaborators and the individuals. The results of “perception” (which represents “the perception of web-based learning”) shown in Table 6 suggest that the former group had a higher mean value (M = 3.7, SD = 11.17) than did the latter group (M = 3.2, SD = 11.59) as the mean difference reached a significance level [t(57) = 2.79, p < .007]. This accounted for a medium effect size (r = .34). Moreover, this construct was comprised of four sub-components, e.g., “effects” (which represents “effects of Google Docs on learning”) and “attitudes.” Overall, the mean scores of collaborators’ perceptions for the sub-components appear to be more positive than those of individuals; the highest mean value (M = 3.9) was loaded in “ease of use,” indicating that the collaborators more frequently agreed that Google Docs was easy to use than did the individuals (M = 3.1). This is followed by the “task design,” which represented the learning activities on Google Docs; the collaborators (M = 3.6) found the learning activities more interesting and useful than did the individuals (M = 3.1).

The independent-samples t-tests was used to compare the mean scores of the four sub-components between the collaborators and the individuals. The statistical results in Table 6 show that apart from the first component “effects,” the mean scores of the three sub-components differed significantly between the groups as the significance values were between .010 and .000. Initially, the collaborators had a higher mean score as stated previously (M = 3.9, SD = 2.01) in the “ease of use” compared to the individuals (M = 3.1, SD = 1.81, t(51) = 3.81, p < .00), and this resulted in a medium effect size (r = .47). However, it is worth mentioning that although the mean scores of the “effects” were not significant between the groups, the sub-component had a noticeable effect size (r = .25) whose value was greater than the small effect size (r = .10).

To answer the second research question regarding the difference in engagement and participation between the groups, the number of attempts made by the groups was calculated; the collaborators group had 87 attempts in total, indicating that each participant had 2.56 trials on average whilst the individuals had 22 in total, meaning that each
participant had less than 1 trial. In Table 7, the differences in the mean scores between the groups were then computed using the independent samples t-tests. As a result, the mean scores of the collaborators group \((M = 2.56, SD = 3.86)\) and the individuals group \([M = .71, SD = 1.46, \(t(63) = 2.51, r = .30\)]\) were different at a significance level \((p < .015)\) with a medium-effect size value.

Table 6. Results of the independent samples t-tests for the construct of perception of web-based learning and its subcomponents

<table>
<thead>
<tr>
<th></th>
<th>Collaborators</th>
<th>Individuals</th>
<th>t</th>
<th>p</th>
<th>Effect size (r)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Perception</td>
<td>3.7</td>
<td>3.2</td>
<td>2.79</td>
<td>.007**</td>
<td>.34</td>
</tr>
<tr>
<td>Effects</td>
<td>3.5</td>
<td>3.2</td>
<td>1.89</td>
<td>.064</td>
<td>.25</td>
</tr>
<tr>
<td>Attitudes</td>
<td>3.5</td>
<td>3.2</td>
<td>2.67</td>
<td>.010**</td>
<td>.33</td>
</tr>
<tr>
<td>Ease of use</td>
<td>3.9</td>
<td>3.1</td>
<td>3.81</td>
<td>.000***</td>
<td>.47</td>
</tr>
<tr>
<td>Task design</td>
<td>3.6</td>
<td>3.1</td>
<td>2.72</td>
<td>.009**</td>
<td>.34</td>
</tr>
</tbody>
</table>

Note. *p < .05. **p < .01. ***p < .001.

Table 7. Results of the independent samples t-tests for the attempts by the groups

<table>
<thead>
<tr>
<th></th>
<th>Collaborators</th>
<th>Individuals</th>
<th>t</th>
<th>p</th>
<th>r</th>
</tr>
</thead>
<tbody>
<tr>
<td>Attempts</td>
<td>2.56</td>
<td>.71</td>
<td>2.51</td>
<td>.015*</td>
<td>.30</td>
</tr>
</tbody>
</table>

Note. *p < .05. **p < .01. ***p < .001.

The above results indicate that collaborators made more attempts than did individuals. In particular, the difference in the number of attempts between the groups had yielded a statistically significant association \((p < .05)\). However, the mean values (2.56 and 0.71) were divided by 8 weeks to see students’ participation every week; this gave mean values of 0.32 for the collaborators and 0.08 for the individuals, indicating a low rate of both groups’ participation. Overall, with these analyses, the collaborators were more actively engaged in the given tasks than were the individuals. To further compare the trials made by the groups over the eight-week period, a graph chart was generated (see Figure 2).

Figure 2. Number of attempts on a weekly basis

In the above chart, the frequency patterns of the two groups were quite similar, in that the two lines gradually rose after the first week but fell drastically after the sixth week. Particularly, the contributions made by all the participants reached the peak level in Week 5, resulting in 37 trials in the collaborators group and 11 trials in the individuals group. The results suggest that the former participated in the vocabulary learning tasks more often than did the latter during the eight-week experiment; both groups made more contributions in the middle of the experiment than in the initial and final weeks.

Discussion

This study examined the experience of collaborative and individual learning in relation to the dimensions of vocabulary gain, motivation and the perception of web-based learning. First, the findings of this study as derived
from the statistical analyses in the preceding section confirm that, compared with the individuals group, the collaborators group was found to have a better vocabulary gain in the posttest. The lexical knowledge gain was further examined by looking into the text corpus of the learners and the results indicate a significant difference in the error repair instances between the groups. Results such as these align with those found in Hwang et al. (2007). It can be explained that although the collaborators had more lexical errors, they had more repair instances and this is assumed to have their lexical knowledge enhanced through negotiated interaction between the collaborators. Second, the collaborators had higher levels of motivational beliefs and self-efficacy and a lower level of test anxiety, as well as a more positive perception towards learning on Google Docs. Apart from the “test anxiety,” all the sub-components differed significantly between the groups ($p < .05$). To some extent, results such as these corroborate some previous studies found in traditional settings, e.g., Pintrich and De Groot (1990), and in web-based environments, e.g., Lee and Tsai (2011).

Regarding the vocabulary knowledge gain which did not differ significantly by the two groups, among many other possible explanations, there are two main ones which may help explain such results. First, it might be attributed to the insufficient period of experiment undertaken to demonstrate the effect of treatment on the lexical knowledge development. Second, according to the study by Kirschner et al. (2009), their findings suggest that due to the limitations of working memory group learners were likely to perform better in the transfer test whereas the individual learners tended to do better in the retention test. With that assumption, the pre-/posttest that this study adopted were retention rather than transfer tests which required the participants’ working memory (remembering linguistic discrete items); thus, the difference in vocabulary gain cannot be distinguished between the collaborators and the individuals group. These findings, hence, suggest investigating further by utilizing different types of tasks, such as using vocabulary recall tests and textual inference tests altogether, to compare the knowledge gain between individual and group learners. In addition, the sub-component “test anxiety” was unlikely to play a pivotal role in influencing both groups of students’ perception of using the web tool collaboratively and individually though the collaborators group appeared to have a slightly lower level of test anxiety than did the individuals group.

Moreover, the results also reveal that the collaborators were participating more actively in the web learning than were the individuals, whereby more students in the collaborators group than in the individuals group practiced the learning activities and this resulted in a significant difference in the attempts between the individuals and the collaborators. Such an assumption is in support of findings regarding social mediation derived from the relevant literature and previous investigations, suggesting that an individual’s cognitive ability and social competence affect his or her learning outcomes or academic performance, e.g., Nokelainen et al. (2005), John-Steiner and Mahn (1996).

As Figure 2 shows, the number of attempts that the participants made indicated the participation or engagement in learning in the web-based environment as it demonstrates that both groups had a low rate of participation as each student in both groups had less than 1 attempt every week, compared with the study by Lee (2012), who reported that each participant in that study posted 3.36 online messages every week and students posted more messages on the due-date, the last day for posting messages. Such students’ learning tendency in that study happened in this study as the participants of this current study practiced the learning tasks on Google Docs more frequently in weeks 4 and 5 than in any other week due to the final exam of the course they undertook, which took place at the end of June, which happened to be in week 5 of the experiment. Hence, the two groups of students were motivated extrinsically rather than intrinsically to study the given learning materials although the collaborators group had a higher level of motivation than did the individuals groups. This can be explained in that students in both groups, as intermediate EFL learners, had a similar level of proficiency in English as well as motivation. Despite this, compared with the individuals, the collaborators made more efforts and contributions to learning during the 8-week experiment, e.g., attempts of using Google Docs. This seems to be consistent with the findings of some other studies, such as Razon et al. (2012), which claim that collaboration influences the behaviour of the collaborators, including motivational resources and participation.

**Conclusion**

This study set out to examine the participants’ learning experience in the web-based environment by adopting the sociocultural theory that social mediation affects students’ learning and perceptions of the constructs (e.g., motivation). The present study is inherently limited by the small sample size as it lacks generalizability to the population. This is further confined to the analyses of quantitative data, such as statistics. That is, the log files
collected from the use of Google Docs, which contained language usage by the participants, merit further investigation in order to track whether they improve the lexical or grammatical knowledge in English over time. Furthermore, further research is needed to look at online collaboration qualitatively, in terms of how learners interact with each other during problem-solving tasks or whether the interaction has some impact on the knowledge gain. Finally, the present study has some pedagogical implications: collaborative learning needs to be implemented in classroom settings by a means of designed learning activities as the learners may transfer the learning behaviour to new environments. Among many other benefits, students will be more capable of thinking critically if they work collaboratively rather than working individually. Hence, it is suggested that usage of the web-based applications has an important role to play when learners are out of the classroom as it promotes collaborative learning which will in turn increase learners’ motivation and engagement in learning.

Acknowledgements

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References


Appendix A

Vocabulary pretest and posttest (Adapted from Stempleski, Morgan, & Douglas, 2011)

Vocabulary test

A. Match each word in the box with its meaning.

<table>
<thead>
<tr>
<th>skip</th>
<th>expire</th>
<th>gym</th>
<th>chief</th>
<th>work out</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. health club</td>
<td>_______</td>
<td>2. main</td>
<td>_______</td>
<td></td>
</tr>
<tr>
<td>3. terminate</td>
<td>_______</td>
<td>4. exercise</td>
<td>_______</td>
<td></td>
</tr>
<tr>
<td>5. miss</td>
<td>_______</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

B. Read the short text and complete the information with the words in the box.

<table>
<thead>
<tr>
<th>messy</th>
<th>laid back</th>
<th>selfish</th>
<th>reserved</th>
<th>bright</th>
</tr>
</thead>
</table>

Jessica and Joan are sisters and they are friendly. Although they are very ________ (intelligent), they are very different. Jessica is very organized as she knows where everything is in her apartment. Someday, she wants to own her company. Joan is very careful with her money. In fact, she’s a little bit ________ - sometimes she doesn’t like to share. Jessica is somewhat _________. She has two or three close friends and doesn’t go out a lot. Joan’s apartment is kind of ________: there are dirty dishes in the sink and magazines all over the floor. Joan enjoys her job and she has a very ________ (relaxed) attitude about life and work.

C. Select each word that best describes its meaning in English.

1. talent
2. ability
3. contest
4. audition
5. appear
6. risky
7. achievement
8. creative
9. private
10. impulsive

D. Select each word that best describes its meaning in Chinese.

1. preserve
2. probation
3. employee
4. muscular
5. scared
6. emergency
7. stomachache
8. rough it
9. obesity
10. gourmet
11. fever
12. franchise
E. Read the short text and choose the best meaning that describes the text.

The movie *Shutter*

In this (1) hit from Thailand, Tun, a (2) photographer, and his girlfriend, Jane, are driving home on a lonely (3) country road one night. Suddenly, they see a girl in the road.

This movie was a (4) remake of a Thai movie with the same name. It was first (5) released in the United States and Canada. The (6) critics thought it would (7) flop, but it did well and made over $45 million (8) worldwide.

The main (9) characters are Jane and her husband, Ben. They move to Tokyo for Ben’s new job. One night, they are in a car accident on a country road. They (10) hit a young girl and drive into a tree. When they wake up, they look for the girl but they can’t find her. Was the girl really there?

1. ______ a. 撞 b. 拍 c. 打 d. 電影
2. ______ a. 探險家 b. 攝影師 c. 科學家 d. 哲學家
3. ______ a. 鄉村小道 b. 高速公路 c. 省道 d. 政府建的路
4. ______ a. 翻拍 b. 重做 c. 製造 d. 電影
5. ______ a. 釋放 b. 主角 c. 上演 d. 電影
6. ______ a. 導演 b. 影評 c. 演員 d. 觀眾
7. ______ a. 賣座 b. 不賣座 c. 表演 d. 公演
8. ______ a. 地區 b. 全世界 c. 美洲 d. 歐洲
9. ______ a. 攝影師 b. 導演 c. 觀眾 d. 演員
10. ______ a. 打 b. 撞 c. 拍 d. 看見
Appendix B

Questionnaire survey

<table>
<thead>
<tr>
<th>Motivation</th>
<th>Items</th>
</tr>
</thead>
</table>
| Motivational beliefs | I like learning new things from a learning task.  
| | What I am learning about this course is important for me.  
| | I like doing English tasks.  
| | I like explaining to others about what I know.  
| | I think that better English skills will help me to get a better job.  
| | I enjoy doing English tasks by myself.  
| | I accomplish tasks without looking at the answers first.  
| | I like brainstorming for English practice tasks.  
| | I like to take challenging English tasks.  
| | I'll get a good grade.  
| | People will respect me if I'm good at this subject. |
| Self-efficacy | Compared with others, I think I’m a good student.  
| | I think that I can do well in this class.  
| | I know a great deal about this course.  
| | I am confident in English learning.  
| | I have good study sills. |
| Test Anxiety | I am upset about the questions that I cannot answer during a test.  
| | I am feeling uneasy and upset before taking a test.  
| | When taking a test, I tend to think about how poorly I am doing.  
| | I tend to worry about tests before taking one. |

<table>
<thead>
<tr>
<th>Perception of learning on Google Docs</th>
<th>Items</th>
</tr>
</thead>
</table>
| Effects of Google Docs on English learning | Google Docs is an effective tool for learning English.  
| | Google Docs helps me English learning tasks effectively.  
| | Google Docs is an effective tool for learning English.  
| | I think that using Google Docs has a great impact on English learning. |
| Attitude | Google Docs helps me accomplish my English tasks.  
| | Using Google Docs increases my English ability.  
| | I like to use Google Docs for learning.  
| | I like using Google Docs. |
| Ease of use | Google Docs is easy to use.  
| | I find it easy to use Google Docs after I was first taught how to.  
| | I became familiar with Google Docs by learning how to use it.  
| | It is easy to remember how to use Google Docs |
| Learning tasks | Learning tasks increase my interest in learning English  
| | Learning activities improve my English ability.  
| | Learning activities are helpful for learning English.  
| | Learning tasks are helpful for increasing knowledge in English. |
Classic Conversational Norms in Modern Computer-Mediated Collaboration

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ABSTRACT

This paper examines whether conversational norms that have been observed for face-to-face communication also hold in the context of a specific type of computer-mediated communication: collaboration (such as in Wikipedia). Specifically, we tested adherence to Grice’s (1975) maxim of relation—the implicit demand to contribute information that is relevant (only) for the purpose of the communication. In two experiments about a historical event, we manipulated the relevance of information provided as well as the context of the collaboration (i.e., encyclopedia article vs. contemporary witness compendium). In line with Grice’s maxim, participants indeed reliably preferred information that was relevant for the specific context (e.g., information of general relevance to a broader audience in the encyclopedia context).

Keywords

Conversational norms, Maxim of relation, Computer-mediated communication (CMC), Collaborative knowledge construction, Wikipedia

Introduction

The Internet increased the possibilities of communication exponentially. One can discuss in forums, follow the posts of others, share digital artifacts and comment on them, and collaborate with people one might not even know. Such computer-mediated communication (CMC) differs profoundly from face-to-face communication (Flaherty, Pearce, & Rubin, 1998), particularly with regard to anonymity, time delay, lack of shared context, lack of immediate feedback and the possibility of simultaneous involvement in other ongoing exchanges (e.g., Atifi, Mandelcwaig, & Marcoccia, 2011; Eklundh, 2010; Herring, 1999; McKenna & Bargh, 2000; Sproull & Kiesler, 1986). One specific form of CMC is computer-mediated collaboration; for example, the collaborative construction of knowledge within the online encyclopedia Wikipedia. Here, authors collaboratively write encyclopedic articles with the goal of collecting and disseminating the world’s knowledge. Despite the differences between CMC and face-to-face communication, one might presume that classic conversational norms operate nevertheless. In this paper we examine this question in the context of computer-mediated collaboration in different kinds of wikis.

Grice’s classic conversational norms

In his widely acknowledged account of conversation, Grice (1975) started from the observation that communication sometimes seems to be incredibly irrational and, at the same time, highly effective. What we say is not always what we mean and thus meaning has to be inferred in order to make a conversation work smoothly (Clark, 1985). But how can anyone reliably infer the meaning that was intended? According to Grice (1975), this is due to shared fundamental norms that derive from a joint interest in a successful conversation — the so-called “cooperative principle,” which prompts communicators to make their “conversational contribution such as is required, at the stage at which it occurs, by the accepted purpose or direction of the talk exchange in which you are engaged” (p. 45). This principle was fleshed out in four maxims. According to these, communicators should make their contribution as informative as is necessary (maxim of quantity). They should be truthful and not say what they believe to be false or anything for which they lack evidence (maxim of quality). Moreover, their contribution should be relevant (maxim of relation) and communicators should avoid ambiguity, obscurity, prolixity and incoherence (maxim of manner).

While Grice (1975) did not expect all people to be compliant all the time, he proposed adherence to be reasonable and thus the default of communication. That is, although we would not trust notorious liars, Grice (1975) proposes that we assume others to be truthful—unless we have reasons to doubt.
For the present purpose, we will focus on the demand to contribute relevant information. This requirement is not only directly expressed in the maxim of relation, but also included in the maxim of quantity (Do not be more informative than necessary) and manner (Avoid prolixity). In offline communication, research has gathered empirical support for a general adherence to this norm. Although minor deviations do occur (Engelhardt, Bailey, & Ferreira, 2006; Rundquist, 1992), major deviations have been found only in profound dysfunctions such as autism (Surian, Baron-Cohen, & van der Lely, 1996) and schizophrenia (Corcoran & Frith, 1996). Hence, people generally comply with the requirement to contribute something relevant (and not more than that). Moreover, violations are often reinterpreted in a meaningful way (Schwarz, 1996; 1999), suggesting that people do expect others to adhere to such a norm (Bless, Strack, & Schwarz, 1993).

But does this extend to CMC? Grice (1975) questioned generalizability to all types of exchange (e.g., letter writing), but essentially, he argued that a genuine interest in the central goal of the communication is crucial: anyone who cares about that “must be expected to have an interest […] in participation in talk exchanges that will be profitable only on the assumption that they are conducted in general accordance with the cooperative principle and the maxims.” (p. 49). Theoretically, then, the Gricean maxims could well hold in the context of CMC—if communicators share a common goal of their exchange. It is desirable to communicate only relevant information (Hambridge, 1995; Newlands, Anderson, & Mullin, 2003; Subramani & Hahn, 2000). Adherence, however, was examined in only two studies and only with regard to redundancy. Both found compliance with the maxim of quantity in the context of newsgroup discussions (Atifi et al., 2011; Eklundh, 2010). For email conversation, in contrast, undifferentiated and unedited quoting of previous messages (i.e., redundancy) was reported (Eklundh, 2010). It may be arguable, however, whether this finding represents a violation of the maxim of quantity, given that the old message appeared below the original contribution and thus did not interfere with it. Nevertheless, this finding indicates that generalization to different kinds of CMC cannot be taken for granted.

**Computer-mediated collaboration with wikis**

In computer-mediated collaboration, the collaboration is mediated by a shared digital artifact, which is edited. When people are working together, successful communication becomes even more important. But no research regarding adherence to conversational norms has yet been conducted in the context of computer-mediated collaboration. The objective of the type of computer-mediated collaboration we are interested is knowledge construction. In this case, authors contribute their own knowledge, edit and rewrite the contributions of others, and collaboratively construct a text that represents their common knowledge (Cress & Kimmerle, 2008; Scardamalia & Bereiter, 2006). In the educational context, wikis are used as collaborative e-learning environments (Li, Dong, & Huang 2011), for the facilitation of primary-school students’ collaborative writing (Woo, Chu, Ho, & Li, 2011) or for the joint development of teaching material (Lin, Lin, Huang, & Cheng, 2013).

One of the most impressive results of computer-mediated collaboration, however, is the online encyclopedia Wikipedia. Here, thousands of users voluntarily contribute to the world’s largest compendium of knowledge (Anthony, Smith, & Williamson, 2009; Halfaker, Kittur, Kraut, & Riedl, 2009). Although users may also communicate directly with each other (Kittur & Kraut, 2008; Viégas, Wattenberg, Kriss, & van Ham, 2007), we will focus on article editing because this reflects the genuine collaboration. We assume that this collaborative knowledge construction is likewise based on conversational norms that guide individual communication. An essential precondition for the successful construction of knowledge is that only relevant information is contributed. But collaborative knowledge construction differs from other types of communication in several ways.

First, it is indirect. A shared digital artifact mediates the collaboration. That is, individual authors communicate by editing the Wikipedia article (e.g., by complementing, revising or reverting others’ contributions). Second, the addressee is unknown and it is a many-to-many communication. Authors who contribute to Wikipedia, for instance, do not know who will read their contributions (or the article in general) nor who might also decide to revise the article. Third, the unique contribution is usually not precisely identifiable, at least not prima facie. Instead, it is embedded in a body of written text and from this it is not immediately visible, who contributed, revised or deleted which part of the text. Such information is only revealed when retrieving the revision history of the article. Hence, collaboration focuses on the result of the artifact-mediated communication; that is, on the artifact itself (e.g., the resulting Wikipedia article).
Conversational norms in the context of computer-mediated collaboration

In sum then, computer-mediated collaborative knowledge construction differs substantially from other forms of CMC. But it is precisely its differentness that renders collaborative knowledge construction interesting. Essentially, it puts Grice’s maxim under rigorous scrutiny: If evidence for the operation of Grice’s maxims were found in the realm of collaborative knowledge construction, this would argue for broad validity of these conversational norms. Moreover, such evidence would in turn indicate that novel and specific forms of computer-mediated communication can be traced back (at least in part) to fundamental norms that underlie daily conversations.

Despite the many differences that characterize collaborative knowledge construction in comparison to CMC as well as classic face-to-face conversations, contributing one’s own knowledge to a shared digital artifact is a communicative act (Cress & Kimmerle, 2008). Accordingly, conversational norms can be assumed to influence collaboration. But whereas truth (maxim of quality) is absolute, relevance (maxim of relation) depends on the communication context and purpose (Grice, 1975). An encyclopedic article about a historical event, for instance, should contain mostly information of general relevance for the event, whereas a contemporary witness article, on the other hand, should contain more information that refers to a specific witness of an event. In order to apply this maxim appropriately, individuals must thus be aware of the specific aim and scope of the shared digital artifact. For encyclopedic articles and contemporary witness accounts and their contents, we presumed that there was a conventional understanding, which was shared by most adults (i.e., holding a schema about encyclopedias, Brewer & Nakamura, 1984). Accordingly, we expected participants to hold differential beliefs about which information was relevant in either context.

We therefore propose that the maxim of relation guides individual behavior in the context of collaboration. To examine this question experimentally, we placed participants in two different contexts (encyclopedia vs. contemporary witness compendium) and assessed which information was preferred (Experiment 1) and actually included (Experiment 2) in an article. To this end, we provided participants with a text about a historical event that contained information of varying relevance: Some information was of relevance for a broader audience (general relevance), some information concerned individuals only (individual relevance), and some information lacked any reference to the event (irrelevance).

If participants adhered to Grice’s maxim of relation, we would expect an interaction between the context (encyclopedia vs. contemporary witness compendium) and the information relevance (general relevance, individual relevance, irrelevance). In the encyclopedia condition, participants should prefer information of general relevance over information of individual relevance (hypothesis 1) and irrelevant information (hypothesis 2). In contrast, in the contemporary witness condition, participants should prefer information of individual relevance over information of general relevance (hypothesis 3) and irrelevant information (hypothesis 4). Also, information of general relevance should be preferred for the encyclopedic article compared to the contemporary witness compendium (hypothesis 5), whereas information of individual relevance should be preferred for the contemporary witness report compared to the encyclopedic article (hypothesis 6).

Experiment 1

Method

Design and participants

Sixty-nine undergraduate psychology students (54 female; \( M_{\text{age}} = 22.22; \ SD = 4.41 \)) participated and received partial course credit as compensation. They were randomly assigned to either the encyclopedia (\( n = 37 \)) or the contemporary witness (\( n = 32 \)) condition. Information relevance (general, individual, irrelevant) was manipulated within subjects. Hence, the study consisted of a 2 x 3 mixed design.
Material

The material consisted of a text about the Football War, which was fought by El Salvador and Honduras in 1969. It was caused by political conflicts and tensions between the two countries and coincided with the inflamed rioting during the qualifying round of the 1970 World Cup. The text was constructed in order to contain sentences with information of different kinds of relevance. Sentences of general relevance referred to historical facts that are relevant to a broader audience (e.g., “The government of El Salvador decided in favour of a military intervention, which started on July 14, 1969.”). Information of individual relevance concerned single individuals only (e.g., “For Pipo Rodriguez, the scorer of the goal that qualified for the World Championship, this game was a turning point in his life.”). Sentences with irrelevant information lacked any reference to the Football War (e.g., “Gerd Mueller, player of the German National Team, was chosen as best scorer of the championship.”).

The initial version consisted of 49 sentences. These sentences were then submitted to a pretest in which thirteen raters were asked to carefully read each sentence and sort it into one of the three categories of information relevance (general, individual, irrelevant), or to indicate that no meaningful categorization was possible. For the final text only sentences upon which at least eight of the thirteen raters agreed were included. Moreover, it was ensured that each category of information relevance contained the same number of sentences (11 each). The final text therefore included 33 sentences in total. The order of the sentences was mixed; readability was unanimously confirmed in yet another pretest (N = 6 students).

Procedure

At the beginning of this online experiment, participants learned that the study was about the perception of historical events. They were asked to read the following text carefully. Afterwards, they were asked to imagine that they were about to contribute to either the online encyclopedia Wikipedia (encyclopedia condition) or to the online wiki of contemporary witness reports (contemporary witness condition). This manipulation was reinforced by the presentation of the Wikipedia logo or an emblem that read “contemporary witness” and continued throughout participants’ ratings. Each of the 33 sentences was then presented again separately, and participants indicated how likely they would include the information into the article (1 = extremely unlikely, 7 = extremely likely). Afterwards, prior knowledge of the war was assessed (none of them had such knowledge), and participants provided reasons for their information selection (open response format). Subsequently, we checked whether participants had realized the existence of (a) generally relevant, (b) individually relevant, and (c) irrelevant information in the text. Finally, demographic variables were assessed.

Results

Alpha was set to .05, p’s reported are one-tailed with regard to t-tests concerning directed hypotheses and two-tailed otherwise.

Manipulation check

The questions of whether generally relevant, individually relevant, and irrelevant information had been contained in the text were affirmed by the overwhelming majority of participants (68, 69, and 65 out of 69 participants, respectively). Hence, participants were aware of different types of information and were thus also able to select the ones they found suitable for the article in question. Internal consistencies of participants’ likelihood ratings were analyzed for each category of information relevance (general, individual, irrelevant). Cronbach’s α ranged from .79 to .95. The sentences of each type of information relevance thus proved to be highly inter-correlated, which allowed for aggregation. All subsequent analyses are therefore based on average likelihood ratings per information category.

Information selection

We first conducted a 2 x 3 mixed ANOVA with condition (encyclopedia vs. contemporary witness) as between-subjects factor and information relevance (general, individual, irrelevant) as within-subjects factor. Our hypotheses
suggest that there should be a significant interaction. This is indeed what we found, $F(2,134) = 55.54, p < .001, \eta^2_p = .45$. Beyond that, the analysis yielded a main effect of information relevance, $F(2,134) = 119.97, p < .001, \eta^2_p = .64$. In order to elucidate the interaction and to test hypotheses 1 through 4 directly, we report planned paired $t$-tests for both between-subjects conditions separately.

As can be seen in Table 1, participants in the encyclopaedia condition indicated that they were significantly more likely to include information of general than of individual relevance, $t(36) = 15.93, p < .001, d = 2.65$, or irrelevant information, $t(36) = 14.11, p < .001, d = 2.36$. Hence, hypotheses 1 and 2 were supported.

Table 1. Mean likelihood of including information

<table>
<thead>
<tr>
<th></th>
<th>Encyclopedia</th>
<th>Contemporary witness report</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$M$</td>
<td>$SD$</td>
</tr>
<tr>
<td>General relevance</td>
<td>6.17</td>
<td>0.64</td>
</tr>
<tr>
<td>Individual relevance</td>
<td>2.18</td>
<td>1.09</td>
</tr>
<tr>
<td>Irrelevant</td>
<td>3.09</td>
<td>0.99</td>
</tr>
</tbody>
</table>

In the contemporary witness condition, participants likewise indicated a higher probability of including information of individual relevance than irrelevant information, $t(31) = 6.13, p < .001, d = 1.10$. There was, however, no significant difference between information of general and individual relevance, $t(31) = 1.24, p = .11$. Hence, hypothesis 3 but not hypothesis 4 was supported.

Hypotheses 5 and 6 were tested in two separate planned independent $t$-tests. Information of general relevance was significantly more likely to be included in an encyclopaedia than in a contemporary witness report $t(54) = 5.13, p < .001, d = 1.28$ As predicted, the pattern was reversed for information of individual relevance, $t(67) = 9.89, p < .001, d = 2.39$. Hence, the data supported both hypotheses.

Additional analyses

We asked participants for aspects that guided their selection of information and inductively identified various categories, which are presented in Table 2. With regard to the encyclopaedic article, objective facts of general relevance and with direct reference to the war seemed most relevant, whereas information concerning individual fates, emotions or evaluations were regarded as undesirable and inappropriate.

Table 2. Desirability of aspects depending on text format (absolute frequencies)

<table>
<thead>
<tr>
<th></th>
<th>Encyclopedic article</th>
<th>Contemporary witness report</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Study 1</td>
<td>Study 2</td>
</tr>
<tr>
<td>Desirable aspects</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Facts</td>
<td>12</td>
<td>7</td>
</tr>
<tr>
<td>Direct reference to the war</td>
<td>9</td>
<td>13</td>
</tr>
<tr>
<td>Dispassion</td>
<td>9</td>
<td>3</td>
</tr>
<tr>
<td>Information of general relevance</td>
<td>8</td>
<td>10</td>
</tr>
<tr>
<td>Objectivity</td>
<td>7</td>
<td>2</td>
</tr>
<tr>
<td>Verifiability</td>
<td>1</td>
<td>–</td>
</tr>
<tr>
<td>Individual fates</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Emotions</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Specificity</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Undesirable aspects</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Individual fates</td>
<td>22</td>
<td>16</td>
</tr>
<tr>
<td>Facts</td>
<td>–</td>
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In the contemporary witness condition, in contrast, participants’ information selection was much more geared to individual fates. With regard to information of general relevance, however, the two conditions were quite similar to one another. Participants in the contemporary witness condition repeatedly argued that information of general relevance about the war was important to ensure a general understanding of the event. Participants’ reasons thus mirror our findings about hypothesis 4 and provide an explanation for why the results did not conform to our expectations.

Discussion

We set out to test whether conversational norms hold in the context of computer-mediated collaborative knowledge construction. The present study suggests that this is predominantly the case. Participants in both conditions reliably preferred relevant information to irrelevant information. Moreover, they preferred information that was relevant for the specific context. Historical facts of broad and lasting relevance were chosen predominantly for an article in an online encyclopedia, whereas information that concerned individual experiences was rather rejected. In contrast, individually relevant information was much more likely to be incorporated in a contemporary witness compendium—interestingly to the same extent as generally relevant information. Participants’ explanations for their selection provided insight into this pattern: They argued that reports about contemporary witnesses should be accompanied by general information. Accordingly, their abstract representation of what kind of information a contemporary witness compendium should contain matched their reasoning.

About half of all participants valued objective information in addition to personal information. Although this was contrary to our hypothesis, it makes sense in that it provides a background in which individual fates may be meaningfully embedded. While one may argue that this ultimately serves the cooperative principle, it points to the difficulty of defining relevance a priori (see also General Discussion).

A major limitation of the current study is that participants only had to judge the likelihood with which they would include certain information into a text. To assess actual editing behavior, we conducted Experiment 2.

Experiment 2

This experiment differed from Experiment 1 only with regard to participants’ task and thus the dependent variables. Instead of assessing likelihood ratings we measured whether they actually did or did not include it in an encyclopedic article/contemporary witness compendium.

Method

Design and participants

In total, 65 participants completed the online experiment. We excluded, however, data from six participants who spent less than two minutes on the page where they were to read and edit the text, because reading the text alone takes about that much time. In line with this reasoning, none of these six participants made a single edit. The subsequent results are therefore based on a total of 59 participants (41 female; \( M_{age} = 25.46 \); \( SD = 6.21 \)). The pattern of results was identical, however, for the total sample.

Participants were randomly assigned to either the encyclopedia (\( n = 32 \)) or the contemporary witness (\( n = 27 \)) condition. Information relevance (general, individual, irrelevant) was manipulated within subjects. As dependent variables we assessed which information participants included in the text they had to edit (i.e., information selection). Additionally, we asked for their reasons and their general evaluations of context-dependent information relevance.
Materials and procedure

We used the same materials as in Experiment 1 and conducted the study online. Participants were told that the study was about the presentation of historical events. Their task was to create an article about the Football War.

Participants were asked to create an article they found appropriate for (a) the online encyclopedia Wikipedia or (b) a contemporary witness compendium (random assignment). Again, this experimental manipulation was accompanied by the presentation of a logo (Wikipedia vs. contemporary witness logo). Participants then received the same text as used in Experiment 1 and were instructed to read it carefully and to edit it. It was stressed that they could engage in any kind of editing—rephrasing, rearranging, adding, or deleting information. Finally, we asked participants why they had selected some information but not other and additionally asked them to indicate which kind of information they found in general to be relevant for (a) the compilation of encyclopedic articles and (b) the compilation of contemporary witness reports.

Results

Manipulation check and analysis

The question of whether generally relevant, individually relevant, and irrelevant information had been contained in the text was again affirmed by the overwhelming majority of participants (58, 55, and 53 out of 59 participants, respectively). Participants’ texts were analyzed and the number of sentences per relevance category (general, individual relevance or irrelevance) was determined. Participants mainly edited at the sentence level (i.e., deleted or kept entire sentences in > 90% of the cases). If only a part of the information contained in a sentence was included into the text, this was counted as half a sentence.

Information selection

To analyze the number of sentences per relevance category included in participants’ texts, we first conducted a 2 x 3 mixed analysis of variance with condition (encyclopedia vs. contemporary witness) as a between-subjects factor and information relevance of the sentences (general, individual, irrelevant) as a within-subjects factor. Consistent with our hypotheses, we obtained a significant interaction of condition and information relevance, $F(2,114) = 9.61, p < .001, \eta^2_p = .14$. Moreover, the analysis yielded a main effect of information relevance, $F(2,114) = 36.37, p < .001, \eta^2_p = .39$. In order to elucidate the interaction and in order to test hypotheses 1 through 4 directly, we conducted planned paired $t$-tests for both conditions separately. As can be seen in Table 3, participants in the encyclopedia condition included significantly more sentences containing information of general relevance than sentences containing information of individual relevance, $t(31) = 7.63, p < .001, d = 1.63$, or irrelevant information, $t(31) = 4.24, p < .001, d = 0.92$. Hence, hypotheses 1 and 2 were supported.

In the contemporary witness condition, participants likewise included significantly more sentences with information of individual relevance than of irrelevant information, $t(26) = 3.09, p < .001, d = 0.60$. Contrary to our expectations, however, they included significantly fewer sentences containing information of individual relevance than sentences containing information of general relevance, $t(26) = 3.06, p < .001, d = 0.68$. Hence, hypothesis 3 but not hypothesis 4 was supported.

Hypotheses 5 and 6 were tested in two planned separate independent $t$-tests. Information of general relevance was significantly more often selected in the encyclopedia condition than in the contemporary witness condition, $t(57) =$
1.64, \( p < .05, d = 0.43 \). As predicted, the pattern was reversed for information of individual relevance, \( t(57) = 2.82, p < .01, d = 0.74 \). Hence, the data supported both hypotheses.

**Additional analyses**

Table 2 provides insight into aspects that guided participants’ selections in each condition. With regard to the encyclopedic article, the pattern mirrors the responses of Experiment 1. Objective facts of general relevance and with direct reference to the war seemed most desirable, whereas information concerning individual fates, emotions, or evaluations were regarded as inappropriate for an encyclopedic article. For the contemporary witness compendium, in contrast, participants did not express as much preference for individual fates as did participants in Experiment 1, and some even found individual fates to be undesirable—although this still occurred less frequently than in the encyclopedia condition.

Our question regarding which kind of information participants found relevant for the respective contexts, in contrast, elicited a very straightforward pattern of results that provided further support for our hypotheses. For an encyclopedic article, none of the 59 participants found personal information to be relevant but all 59 participants affirmed the relevance of objective information. For a contemporary witness compendium, in contrast, personal information was judged to be as relevant (selected by 44 out of 59) as objective information (selected by 41 out of 59). Accordingly, more participants had quoted objective information for an encyclopedic article compared to the contemporary witness report (59 vs. 41) and fewer participants found personal information relevant for an encyclopedic article than they did for a contemporary witness account (0 vs. 44).

**Discussion**

We sought to replicate the findings of Experiment 1 with actual behavior as a dependent measure. The general pattern of results was identical. Participants’ information selection was context-specific, which hints towards compliance to Grice’s maxim of relation. For an encyclopedic article, mainly historical facts of broad and lasting relevance were selected, whereas information concerning individual experiences was mainly deleted. In contrast, individual fates were significantly more often included in a contemporary witness compendium—although less frequently than generally relevant information. Similar to Experiment 1, however, participants argued for the relevance of general information about the event in order to present the individual fate in a meaningful context. The lower number of sentences of individual relevance included deserves a few words, however. Possibly, this finding is due to our material because the text contained information about individual fates of different persons. Many participants in the contemporary witness condition wrote a report about one contemporary witness, however. Consequently, they deleted all sentences concerning other individuals. In Experiment 1, in contrast, participants did not need to choose between individuals because they were not required to create a cohesive text. Rather, they were asked only to indicate how likely it was that they would include a given sentence into a hypothetical contemporary witness report. Without specifying this hypothetical report, it is possible to think of different reports for the different individual fates—or not to think about its concrete realization at all.

The assessment of actual behavior provided other valuable insights as well. It suggested that participants in the contemporary witness condition had the more demanding task. They did not only have to choose among different persons, but also had to rearrange the general event information in order to provide a coherent text that fit the experience of the chosen contemporary witness. A few participants even opted for a narrative from the first-person perspective, and one participant made sure to present only event information that the chosen contemporary witness was able to know. These elaborations suggest that the task in this condition was more challenging and made more editing necessary.

Another aspect that needs to be discussed regards irrelevant information that was included into the texts. For both conditions we would have expected information to be deleted that was neither directly related to the war itself nor to any experience of a contemporary witness of that war. Nevertheless, even the irrelevant information was related somehow to the Football War. The last three sentences of the text, for instance, which had been included by many participants, referred to the championship qualification forty years after the Football War, the game between Honduras and El Salvador and measures to prevent any incidents. Surely, this information did not add to the Football
War in describing or explaining it. But the Football War had resulted from the game and so this information could arguably be evaluated as (sufficiently) relevant to be included into the text. Essentially, this observation once more outlines the difficulty of defining relevance a priori and of drawing a precise line between relevance and inappropriateness. Probably, the results would have been different if the irrelevant information contained in the text had indeed lacked any reference to the war.

**General discussion**

Taken together, the two studies provide converging empirical support for Grice’s maxim of relation and thus replicate earlier findings (Atifi et al., 2011; Eklundh, 2010). Major extensions include (1) the investigation of the maxim of relation and its context-dependency, (2) the setting of collaborative knowledge construction, and (3) the internal validity of the present findings due to our experimental approach. Furthermore, our findings are validated by additional observations (participants’ reasons for information selection as well as their understanding of what information is relevant in which context).

Despite the fact that our general pattern of results conformed to our hypotheses and thus argues for participants’ adherence to Grice’s maxim of relation, it is necessary to acknowledge some unexpected findings.

Participants selected more information of general relevance and more irrelevant information than expected in the contemporary witness condition. We have already outlined a meaningful interpretation of these deviances. One may even argue that these findings are in line with Grice’s cooperative principle. The provision of generally relevant information may provide a meaningful background into which an individual experience may be embedded. Also, some of the information categorized as irrelevant in terms of their lacking direct reference to the actual event may be viewed as relevant in terms of a different link to the event (e.g., its consequences).

These elaborations lead us to a very important aspect: Our unexpected findings clearly illustrate that our research question is not a trivial one. Our overall pattern of results makes sense as it is and may thus seem to be obvious. But the deviances from our theoretically derived hypotheses point out that this impression is likely to result from the benefit of hindsight (Slovic & Fischhoff, 1977). A similar case can be made for the observation reported by Eklundh (2010). Here, unedited quoting of previous messages in email conversations was initially viewed as flouting Grice’s maxim of quantity. After all, if one includes the entire previous email in one’s response, there is a maximum of redundancy (as the recipient will receive his or her own message again in full length). Such has been interpreted as a violation of the conversational norm to be as informative as necessary, but not more informative. However, the redundant text did not interfere with the original conversational contribution because it was automatically included and displayed below the response (i.e., non-redundant information). So it is arguable whether it indeed represents a violation of Grice’s maxim of quantity and whether the initial hypotheses still make sense.

When trying to use foresight, it is much more difficult to define information relevance. Additional support for this notion is the fact that agreement upon the type of information relevance in the pretest was far from perfect. Although we had included only sentences upon which eight of the thirteen raters had agreed, this also means that up to five raters had placed the same sentence in a different category of information relevance. (Recall, however, that the sentences that were finally included for each type of information relevance proved to be useful, as indicated by their internal consistencies.) In sum, we conclude that the investigation of adherence to conversational norms—Grice’s maxim of relation in the present study—is not trivial, even though in hindsight it may seem to be. On the contrary, this investigation clearly indicates a need for further research to arrive at a better understanding of conversational norms and their observance in computer-mediated contexts.

One potential limitation needs to be addressed at this point. Female participants were overrepresented in our samples. Previous research indicates that flouting of Grice’s maxims is more prevalent among men than women (Rundquist, 1992). Could our findings thus be biased? In order to test this, we reran all analyses with gender as additional between-subjects factor. In none of the cases did we obtain a significant impact of gender. The possibility that female participants might show a particularly pronounced pattern cannot be ruled out (as suggested by Rundquist, 1992), however. Essentially, this might be a specific research question for future studies.
Our investigation focused on one aspect—relevance. Although it is implied in several of Grice’s maxims (Relation, Quantity, Manner) generalizability of our findings to other aspects and maxims has to be tested. Viégas and colleagues (e.g., Viégas, Wattenberg, & Dave; 2004; Viégas, Wattenberg, Kriss, & van Ham, 2007) analyzed collaborative knowledge construction in Wikipedia and found evidence of vandalism, such as the complete deletion of previously gathered knowledge. This destructive editing represents a radical break with the Gricean cooperative principle and indicates indifference to the central goal of the Wikipedians, namely knowledge construction. Another question for further research is how such destructive communication differs between the computer-mediated context and the face-to-face context. We assume that the specific type of communication (e.g., CMC vs. face-to-face conversation) and the respective characteristics eventually turn out to have little impact as long as all communicators share an interest in the central goal of their communication (Grice, 1975; see also Baytiyeh & Pfaffman, 2010; Jadin, Gnambs, & Batinić, 2013; Yang & Lai, 2010). It may seem that a shared goal would be most evident in the context of collaboration, but previous research also from other contexts, supports Grice’s assumption that people generally have a shared goal in their communication in most cases (cooperative principle). After all, communication would be pointless if they did not.

What are the consequences of our findings from an educational point of view? We assume that educational technology does not change collaboration in general as long as communicators have a shared goal. Conversational norms (e.g., the maxim of relation) seem to hold also in computer-mediated settings. From this perspective, the main question is not whether technology could or should be used in schools, universities and other educational contexts but how technology should be designed to support collaborative knowledge construction and foster the active participation of learners.

Wikis (and other educational technology) are more than a technological tool. Their value lies in their implicit norms and guidelines of how to use them. Presenting an encyclopedic wiki in an educational setting, for example, should influence which kind of information learners introduce and how they work on the existing text compared to other kinds of wikis or similar tools. The didactical design of educational technology implicitly shapes its application. We assume that even implicit psychosocial principles of wikis, like the self-organization of the community or the diversity and autonomy of participants (Moskaliuk & Kimmerle, 2009) influence how learners use the wiki to communicate and collaborate. These implicit norms should be discussed with the learners to make them explicit and to facilitate successful learning and collaboration. Another important aspect is that learners need a new kind of information literacy, which is necessary for active participation in open collaboration and knowledge construction (Forte, 2015). They have to consciously exercise purposeful and constructive communication oriented towards building knowledge. As a result, they necessarily become an active part of a knowledge construction community (and society). One way of supporting this process is to use scripts that support wiki-based collaboration and to structure the mutual revision of contributions (Wichmann & Rummel, 2013). This could foster the development and adherence to conversational norms in educational settings.

**Conclusion**

Grice’s maxim of relation is valid even in the context of computer-mediated collaborative knowledge construction. This leads to two important conclusions. First, our findings argue for the pervasiveness of Grice’s conversational norms as computer-mediated collaborative knowledge construction differ in many regards substantially from face-to-face conversations, which Grice had in mind when formulating his maxims. Second, our results argue that new technology does not necessarily come along with new rules and new outcomes (e.g., lower quality). Because they have become increasingly important in our society, computer-mediated communication and collaboration should be an integral part of education.

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Evaluation of iTunes University Courses Through Instructional Design Strategies and m-Learning Framework

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ABSTRACT

As mobile learning technology promotes learning accessibility and flexibility, students benefit from social interactivity and connective learning process which will also foster students’ performance and satisfaction on learning content. The primary purpose of this research was to evaluate iTunes U courses based on instructional design strategies and the m-learning framework. A total of 27 iTunes U courses were selected and evaluated based on the following criteria: (a) The course is provided by institutions of higher education; (b) the course should include instructional design components. The results revealed that all courses scored notably higher means on Content Chunking and Objective and Content Structure. However, all courses were rated low mean scores on the Instructional Strategies categories of the following attributes: Learning Engagement, Feedback, and Evaluation. Moreover, the results revealed that all courses scored notably higher means on one of the m-learning framework which is Customisation and were rated low mean scores on the Conversation attribute. The overall conclusion of this study is that the selected iTunes U courses showed some strengths but considerable weaknesses in meeting the instructional design strategies and m-learning framework. Recommendations are provided for turning mundane courses into dynamic, user-friendly ones where students are excited about their learning.

Keywords

Distance education, Mobile learning, Instructional Design, Pedagogical issues

Introduction

The emergence of mobile or handheld devices (iPod, iPad, smartphone) offers opportunities for learners to access information anywhere, anytime and to connect with global learning communities at their fingertips. Mobile devices allow individuals to post, comment and share information regardless of geographic location or time, which expands their social presence (Engel & Green, 2011). Mobile technology has a myriad of uses, from education and networking to personal productivity (Lunsford, 2010) while it offers multimedia content delivery and creation options. In the 20th century, e-learning emerged because of the rapid developments of network infrastructure and the innovative notion of teaching in a virtual environment. However, the instructional design principles and teaching strategies for e-learning are not necessarily applicable in the design of m-learning (Siemens, 2002). Traxler and Kukulska-Hulme (2005) described m-learning as “a personal, unobtrusive, spontaneous, ‘anytime, anywhere’ way to learn and to access educational tools and material that enlarges access to education for all” (p. 1).

Mobile technologies offer opportunities for instructors to create media-rich and active learning materials which enhance students’ experience in realistic and authentic learning tasks. Students are encouraged to learn the real-world activities and tasks that are relevant to the workforce of the future. Moreover, the characteristics of the iPad, such as ubiquity, access, richness, flexibility ensure students the ability to connect with active instruction and social networks anywhere anytime. Mobile devices promote collaboration among students and extend learning beyond the classroom. M-learning is a subset of e-learning, a step toward making the educational process just in time, just enough and just for me (Peters, 2007). Mobile technology not only promotes student engagement and foster student creativity, but it is an important part of pedagogical and logistical support for implementing iPad in classroom (Cochran, Narayan, & Oldfield, 2013; Falloon & Khoo, 2014; Morrone, Gosney, & Engel, 2012). Cochran’s (2014) review of the literature indicated the following common shortcomings in the majority of m-learning research: (1) lack of explicit underlying pedagogical theory (Traxler & Kukulska-Hulme, 2005); (2) lack of the importance of pedagogical integration, i.e., aligning the affordances of m-learning with appropriate assessments or activities (Laurillard, 2007); and (3) lack of the explicit student and lecturer support and scaffolding (Attewell, 2008). Thus, before designing m-learning...
instruction, instructors or instructional designers need to realize that m-learning is not about the devices and technology, but the capabilities and experience. Effective and proper usage of those capabilities open the doors to a higher level of personalized learning by delivering the right materials to the right person at the right time and place (Brown, 2010). Only a few theoretical and practical frameworks that guide the m-learning instructional design and development processes have been discussed. There is a strong need for integrating m-learning pedagogy and applicable instructional design strategies for developing and assessing m-learning courses and applications.

iPad-supported learning environment

According to the International Data Corporation (IDC, 2012), the number of mobile users in projected to increase from 174 million in 2012 to 265 million in 2016. In September, 2012, Tim Cook, CEO of Apple Inc., revealed that Apple has sold 84 million iPads. Due to the popularity of the iPad, numerous schools and universities around the world are embracing iPad into their classrooms and it is used predominantly by teachers. The proliferation of mobile devices and increasing capabilities of smartphones are changing peoples’ lifestyles. As of 2012, the App Store offered more than 300,000 apps in just about every imaginable category. The iPad has functional qualities, which make this device an appropriate tool for educators to use in the classroom (Apple, Inc., 2013) and wide array of apps have been offering unique affordances particularly suited to educational use (Dhir, Gahwaji, & Nyman, 2013).

Several studies (Falloon & Khoo, 2014; Hoffman, 2013; Miller, Krockover, & Doughty, 2013) had focused more on students’ learning outcomes from iPad use in the learning environment. Manuguerra and Petocz (2011) pointed out that integrating iPad into tertiary education can offer opportunity for instructors to apply and implement effective and efficient pedagogy in an easy and intuitive way. This potential advantage will enhance student on-task engagement. Moreover, Fisher, Lucas, and Galstyan (2013) considered iPad as an efficiency tool for collaboration activities. They argued that its portability, multiple viewing angels and abilities facilitate an collaborative learning environment that allow students to opt between individual and group learning spaces effectively and efficiently. In addition, Borgman et al., (2008) defined cyberlearning as “the use of Web 2.0 networked computing and communications technologies to support learning” (p. 5). Web 2.0 tools and mobile apps can be used in the classroom for various purposes including presentation, communication, research, and document sharing. Research showed that properly use of Web 2.0 tools and mobile apps in the classroom could motivate (Dohn, 2009; Lin & Jou, 2012) and engage (Schneckenberg, Ehlers, & Adelsberger, 2011) students’ learning.

iTunes U learning environment

Apple launched iTunes U in May 2007, a section of the iTunes Store, dedicated to distribution of educational audio and video by universities and institutes from around the world. In January 2012, Apple unveiled a new education-related App called iTunes U Course Manager, that allows educators to create their own courses. It is a web-based tool that can bundle word documents, PDF, audio and video files together (Heim, 2012) and is currently cooperating with educational institutions and non-profit organizations to provide free resources to students. According to Yerrick (2013), there are over 900 universities working with iTunes now creating, capturing, and disseminating content on a subscription basis. One example is the “Stanford on iTunes U” (http://itunes.stanford.edu/) that includes two project sites providing access to audio and video content from schools, departments, and programs across the university: The public site which includes Stanford course lectures, faculty presentations, event highlights, music, and more; the access-restricted site that offers audio and video recordings of lectures (plus supplemental materials, assignments, exams, and posts) from actual courses only to Stanford students. Originally, iTunes U had capability to store audiovisual, podcasting, and video and are used to design and distribute courses that go beyond traditional print media. Furthermore, students can proactively annotate and contribute on digital content, so they become a co-creator of the learning materials and knowledge. The iTunes U Course Manager takes a step further that can be utilized to design a full learning course and apply instructional practices within the platform. The iTunes U course manager provides more functions for instructors to develop clear and detailed course outlines, to distribute course content through learning modules that associated with learning objectives and goals, and to provide feedback for learners to emphasize the important topics.

Shuler (2009) suggested that researchers should consider current application-based m-learning environments to determine the effectiveness of instructional delivery through the use of applications. Only a few studies investigated
iTunes U’s quality on instructional design and assessed learners’ experiences in academic perspective. Thus, there is reason to continue evaluating iTunes U as a potential learning supplement platform in higher education (Yerrick, 2013). Peranginangin and Alamsyah (2013) assessed iTunes U on user experience and they concluded that iTunes U fulfils the device usability aspect of mobile learning platforms by providing high quality multimedia as data output. However, they also pointed out that the weakness of iTunes U is its social aspect. It doesn’t provide social communications making it difficult for learners to interact with each other in the learning process.

**Instructional design strategies**

Instructional design is the systematic development of instructional specifications that follow learning and instructional theory to ensure the quality of instruction. It is the process of analysis of learner’s needs and learning goals and the development of a delivery system to meet those needs (Siemens, 2002). The strategies practiced in the courses, such as content analysis/chunking, realistic objectives, learning engagement/feedback for students and evaluation throughout the process are important factors for learning to take place. According to Smith (1988), design of instruction can serve as a balancing act between providing enough support for students to excel in their learning while limiting, at the same time, enough support to allow them to engage in their own learning. Students must be aware of what they need to know to master course content. The objectives must be clear and attainable, otherwise frustration may cause students to drop out of online classes. Feedback is crucial for student learning to happen. The following paragraphs will describe the categories of instructional design strategies that are important for the framework of this study and development of the instrumentations.

**Course structure**

Instructor needs to ensure that course outline clearly communicates what the students will be expected to learn and do in the course and what procedures for them to follow to complete course works. In addition, course syllabus that outlines expectations and requirements for successful completion of the course and it is essential for students to manage and assess their learning processes.

**Content presentation**

Chunking information of eLearning content is particularly important for online learning. In online learning environment, students are unable to receive real-time feedback and guidance from the instructor. Thus, eLearning content has to be organized in a logical and progressive way that is scaffolded (supportive structures) through chunking in order to accommodate learning cognition limitations.

Content sequencing is the efficient ordering of content that it is important to help the learner achieve the objectives (Morrison, Ross, Kemp, & Kalman, 2010). In addition, appropriate, logical, and hierarchical sequence needs to be determined by the instructor or instructional designer in order for learner to have the most benefit from the learning content. Particularly, hierarchical sequencing is presenting all the major sub-steps separately before integrating them into a step in the sequence.

According to Morrison, et al. (2010), instructional objectives perform three important functions on learning instruction and activities. First, they offer a means for the instructional designer and instructor to design appropriate instruction, specifically to select and organize instructional activities and resources. Second, instructional objectives provide a framework for devising ways to evaluate student learning. Third, objectives guide the learner to identify the skills and knowledge they must master. Learning objectives for each unique activity, learning unit, and overall learning process need to be specified and structured clearly through the course.

**Instructional strategies**

Effective learning requires students to engage proactively in learning activities (Hu & Hui, 2012) and social interactions. Students become active learners when they engage more in learning activities and take charge of their
learning, which leads to favorable learning outcomes (Hiltz & Shea, 2005). Moreover, studies have found that instructional strategies, such as learner-centered instruction (Blumberg, 2009; Doyle, 2011; Harris & Cullen, 2010), active learning (Trowler, 2010), and collaborative learning activities (Ku, Tseng, & Akarasriworn, 2013; Noohi, Abaszadeh, & Maddah, 2013) can promote learning engagement.

Students need to know upfront how the objectives and evaluations connect to their learning. Evaluation is an ongoing process from beginning to end in the instructional design process. Course rubrics are frequently used to determine when objectives have been met for assignments. All courses need to have summative (midpoint in the class) evaluations to see how students are progressing in the course so instructors can intervene when necessary to alleviate problems that are identified. Clark (1995) divides instructional design evaluation into two broad categories: formative evaluation and summative evaluation. Formative evaluation (internal) is judging the worth of instruction while activities are occurring. Summative evaluation takes place at the end of instruction and focuses on outcomes. Summative evaluation (at the end of class) may be in the form of exams administered to students to see if they mastered the content.

M-learning pedagogical framework

Kearney, Schuck, Burden, and Aubusson (2012) proposed a m-learning framework that includes three pedagogical constructs: Personalisation, Authenticity, and Collaboration. For each of these three constructs, they formulated two sub-scales (See Figure 1). According to Kearney et al. (2012), these three constructs are referred to as the following: First, m-learning experiences are typically customized at both a tool and activity level. Users can enjoy a sense of intimacy by bringing and using their personal devices for learning. Second, task authenticity refers to the extent to which tasks are realistic and offer problems encountered by real world practitioners. Mobile learning is inherently situated and dynamic and it occurs in authentic contexts. Learning progress typically involves high degrees of “task and process authenticity” (Cognition and Technology Group at Vanderbilt, 1990) as learners participate in rich, contextual tasks (setting, characters, tools), involving “real-life” practices. Problems, challenges, and explorations that mobile learners encounter allow a deeper understanding to be achieved (Herrington, Herrington, & Mantei, 2009). Finally, recent pedagogical frameworks highlight the importance of conversations (e.g., Laurillard, 2007; Sharples, Taylor, & Vavoula, 2007) and social interactions among learners. Tectonic shifts in society also have impact on learning where it is no longer an internal, individualistic activity. Learners are encouraged to connect with global learning communities, access information technology resources, and become involved in the knowledge creation process in order to make learning effective. Siemens (2005) also pointed out that learning is a process of connecting specialized nodes or information sources and it is necessary to develop and maintain connections between numerous perspectives, opinions, and concepts in order to facilitate continuous learning.

Figure 1. M-learning pedagogical framework adapted from Kearney et al. (2012)
Purpose and significance of the study

Specifically, the study focused on three primary purposes: (a) Provided mobile learning pedagogical framework and instructional design strategies that can increase learning engagement, presence, and flexibility; (b) Investigated mobile technology applied on iTunes U courses to identify mobile learning courses’ strengths and weaknesses; and (c) Put pedagogical framework and course design principle theories to a mobile learning course design into practice. The study served as a model for instructors who wish to incorporate mobile technology in the classroom. The findings of this study benefit educators in their instructional design practices and m-learning instructional developments. The following research questions were addressed:

• What are the strengths and weaknesses of the selected iTunes U courses in meeting the instructional design strategies?
• What are the strengths and weaknesses of the selected iTunes U courses in meeting the Kearney, Schuck, Burden, and Aubusson’s (2012) m-learning framework?

Methodology

Review team

The criteria for selecting members of the review team were: (a) knowledge of learning and teaching; (b) knowledge of information and instructional technology; and (c) knowledge of instructional strategies. Three review team members who meet all three required criteria were selected and their qualifications were listed as followings:

• One review team member is an instructional designer and has professional experience in both the corporate and education sectors for over seven years. He has conducted research and presentations in the areas of online collaboration, instructional technology, and information literacy skills. His research interests include online group development, problem-based instruction, and innovative learning technologies.
• One team member teaches Instructional Design in the Library Media program and has designed and implemented 10 new totally online courses currently being taught. She teaches her students the critical thinking and decision-making skills they need through problem-based and collaborative learning strategies.
• One member has worked in two academic libraries for more than seven years, mainly supports online students and faculty using the digital resources in the library. She has been working on projects and library instructions that are integrating advanced information technology and innovative instructional strategy to effectively enhance library patrons’ information literacy capability.

Selection and sampling of the courses

The iTunes U courses that were selected to be evaluated must meet the following criteria: (a) The course is provided by institutions of higher education; (b) the course should include instructional design components. For instance, learning goals and objectives are clear written and are measurable for measuring desired learning outcomes; instructional strategies are clearly described and are easy for students to follow; communication activities are designed to help students building a learning community, etc. The keywords used for searching iTunes U courses in four fields were listed as followings:

• The field of Library and Information Science - The review team searched for iTunes U courses to evaluate using the following key words: Library, library science, and library information science. However, no course was found that implied an adequate amount of instructional design or m-learning components.
• The field of Education - The key words used to search for iTunes U courses were: Education, teaching and learning in education, teaching strategies, educational technology, and instructional design. The review team decided that only 9 courses were worthy for evaluation.
• The fields of Business and Finance - The following key words were used: Business, business marketing, finance, and financial study; and ten courses were selected.
• The field of Science - The set of key words used for courses in the field of Science were: Science, science and engineering, natural sciences, and computer sciences. The review team decided to select 8 courses that met all criteria.
Instrumentation

To evaluate those selected iTunes U courses, two instruments were developed by researchers of the present study: (a) Measures of Course Development and Instructional Design: Three categories (course structure, content presentation, and instructional strategies) that consists of eight attributes were used to evaluate the selected iTunes U courses from the perspective of instructional design strategies; (b) Measures of m-learning Pedagogical Framework: Three pedagogical constructs that consists of six attributes in Kearney et al.’s (2012) m-learning pedagogical framework were used to evaluate the selected iTunes U courses. All attributes were measured on a 5-point Likert-type scale.

Data analysis

The data analysis in this study involved descriptive analysis. In order to answer two research questions, means of all instructional design strategies and m-learning framework attributes were calculated and reported in the results section. The SPSS 21.0 for Windows was utilized to perform the above analysis.

Results

In terms of the sampling process of the iTunes U courses, a majority of search results were iTunes U Episodes and iTunes U Collections and their purposes focus on library seminars, library tutorials, and library information on services and resources. Results also showed more courses that contained topics related to learning materials such as podcasts, videos, course documents, and resource links that contained more instructional structures. Moreover, most of these courses still lacked specifications on course outlines, learning objectives, and assessment strategies. The review team found one higher education institution that offered an impressive amount of iTunes U courses, but the majority of them were far from being solid well-developed ones that followed instructional design and m-learning frameworks.

Evaluation of instructional design strategies

Research question one examined how successful are the selected iTunes U courses in meeting the instructional design strategies (See Table 1). The results revealed that courses in the fields of Education ($M = 4.75, SD = 0.46$) and Business and Finance ($M = 4.50, SD = 0.85$) scored notably higher means on Content Chunking, compared to courses in the fields of Science ($M = 3.88, SD = 0.83$). Moreover, courses in the fields of Education ($M = 3.88, SD = 1.64$) and Business and Finance ($M = 3.70, SD = 0.82$) also scored notably higher means on Objective and Content Structure. All courses were rated low mean scores on the Instructional Strategies categories by the review team: Learning Engagement (Business & Finance, $M = 1.20, SD = 0.63$; Science, $M = 1.00, SD = 0.00$; Education, $M = 1.13, SD = 0.35$), Feedback (Business & Finance, $M = 1.70, SD = 1.06$; Science, $M = 2.00, SD = 0.00$; Education, $M = 1.00, SD = 1.00$), and Evaluation (Business & Finance, $M = 2.60, SD = 1.07$; Science, $M = 2.38, SD = 0.92$; Education, $M = 1.13, SD = 0.35$).

<table>
<thead>
<tr>
<th>Category</th>
<th>Attribute</th>
<th>Description</th>
<th>Means (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Course Structure</td>
<td>Clear course outline</td>
<td>Include clear course outline:</td>
<td>Education (N = 9)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Show chucking information in outline</td>
<td>3.25 (1.04)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Show summary schedule of sessions</td>
<td>Business &amp; Finance (N = 10)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Provide syllabus</td>
<td>3.90 (0.74)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Science (N = 8)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>3.25 (0.71)</td>
</tr>
<tr>
<td>Content Presentation</td>
<td>Content Chunking</td>
<td>Instructional content is chunked/self-contained units</td>
<td>4.75 (0.46)</td>
</tr>
<tr>
<td></td>
<td>Sequential Presentation</td>
<td>Presentation in sequential, logical order</td>
<td>4.63 (0.74)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>4.50 (0.85)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>3.88 (0.83)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>4.00 (0.63)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>0.53 (0.53)</td>
</tr>
</tbody>
</table>
Hierarchical Presentation

- Fundamental/foundational content presented by objective of this session, then followed by the preparation for the next session

Objective and Content Structure

- Objectives were easily located within the course. Objective and structure stated at the start of the content

Instructional Strategies Learning Engagement

- Learner-centered and active learning potentials:
  - Group discussion using discussion board or blog
  - Presentation of group work
  - Share works with classmates

Feedback

- Provides feedback about progress through frequently asked questions and formative evaluation

Evaluation

- Includes evaluation of conceptual understanding through:
  - Frequently asked questions
  - Post tests
  - Quizzes/exams

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**Evaluation of m-learning pedagogical framework**

Research question two examined how successful are the selected iTunes U courses in meeting the Kearney, Schuck, Burden, and Aubusson’s (2012) m-learning framework (See Table 2). The results revealed that courses in the fields of Business and Finance scored notably higher means on Contextualisation ($M = 3.44, SD = 1.06$), compared to courses in the fields of Science ($M = 2.38, SD = 0.52$). Moreover, courses in the fields of Business and Finance ($M = 3.22, SD = 0.92$) and Science ($M = 3.38, SD = 0.74$) also scored notably higher means on Agency, compared to courses in the fields of Education ($M = 1.44, SD = 0.73$). All courses were rated low mean scores on one Collaboration category by the review team: Conversation (Business & Finance, $M = 1.22, SD = 0.63$; Science, $M = 1.00, SD = 0.00$; Education, $M = 1.00, SD = 0.00$). It is worth mentioning that Education iTunes U courses modules were least effective in all m-learning pedagogical components. Further discussions and recommendations for course design improvements are provided in the next section.

**Table 2. Measures of m-learning pedagogical framework**

<table>
<thead>
<tr>
<th>Category</th>
<th>Attribute</th>
<th>Description</th>
<th>Means (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Education (N = 9)</td>
</tr>
<tr>
<td>Personalisation</td>
<td>Customisation</td>
<td>Activities are customized for the learner to meet their different learning style and approaches: Web Link, Podcasting, Video Lectures, Papers, iBook, Apps etc.</td>
<td>3.00 (0.50)</td>
</tr>
<tr>
<td>Agency</td>
<td></td>
<td>Learners can make decision and are in control of their learning</td>
<td>1.44 (0.73)</td>
</tr>
<tr>
<td>Authenticity</td>
<td>Contextualisation</td>
<td>Learners participate in rich, contextual tasks (setting, characters, tools), involving “real-life” practices.</td>
<td>1.78 (1.30)</td>
</tr>
<tr>
<td></td>
<td>Situatedness</td>
<td>Collaboration includes authentic tasks that provide real world relevance and personal meaning</td>
<td>1.22 (0.44)</td>
</tr>
</tbody>
</table>
Collaboration  Conversation  Instruction fosters social interactions among learner by open, global conversations amongst learners  1.00  1.22  1.00
Data sharing  Instruction makes rich connections with content, other learners and resources.  2.22  3.00  2.63

Discussion

There has been very little research understanding how iTunesU courses are designed and developed and exploring their uses as a teaching and learning tool across disciplines in higher education. This study contributed to the literatures and knowledge in the field of mobile tools for personalized and active learning. The rapid development of technologies has made a big impact in personal life of individuals but also significantly influences the dynamic of learning. Instructors and instructional designers need to pay closer attention to the perspective of learners’ experiences and their abilities to be critical thinkers rather than allowing technology-driven approaches to control instruction (Harris & Sullivan, 2000). In the following section, the researchers identified instructional design weaknesses and recommendations that can improve iTunes U courses. As part of the revamping design process, the weaknesses can become instructional strengths. In many cases, instructional designers may be cognizant of the best practices, but fail to apply them effectively. They ignore the importance of certain design strategies in their attempt to include sufficient content available in a variety of locations throughout the course. As a result of these practices, the course is not as student-centered or learner-friendly as it could be. Students begin to feel frustrated and lose interest in the course.

Course development and instructional design

With respect to the first research question dealing with the evaluation of selected iTunes U courses’ strengths and weaknesses in meeting the instructional design strategies, the results suggested that clear course outline is included and descriptions of each learning unit are presented in an organized manner. Moreover, content is chunked in manageable segments and it flows in a logical progression. Hence, students can easily follow those guidelines to plan their learning process and navigate course content in an efficient way. In comparison to iTunesU courses in other two fields, Science courses revealed notable low score in particularly on attribute of Objective and Content Structure. This did not mean that science instructors do not see the importance of declaring learning objectives for course and learning activities. However, they should realize that it is an essential element for students to understand what they are expected to learn and to achieve in the course. Learning objectives need to be clearly written at the appropriate level and reflect desired outcomes, other than that, they need to be made available in a variety of areas in learning content (syllabus, each learning unit, and each assignment) for students to easily locate them. Overall, those courses are not designed in a way to engage students in the learning process and enhance a knowledge-sharing opportunity in a socio-cultural learning environment. Instructors who plan to use iTunes U as a m-learning platform for teaching should also focusing on fostering social presence via quality communication media and communication sequence (Kekwaletswe, 2007). If students are not encouraged to be engaged in their learning, they might set a low standard and just try to barely pass the course. Therefore, purposefully design active learning activities (i.e., group discussion, role-playing, and debates) and encourage students to participate and engage with classmates will enrich their learning experience and make learning more meaningful. Without doubt, acquiring, sharing, and processing knowledge are all essential activities of learning. Students also expect themselves to give and receive feedback to feel that they are part of learning and by sharing knowledge and arguing with others can enforce them to think critically.

M-learning pedagogical framework

Based on the study results, instructors focused on more of content delivery features than collaborative learning activities in iTunes courses. One of the reasons is that collaborative tools are not being well developed in the course
manager. Instructors have to seek a third party’s applications to fulfill the needs. One drawback to the course design showed that learners taking the courses made very few decisions to control their own learning because most of the content is structured. Little provision was made for presentations of group work in the courses so students could share their work with classmates. Collaboration, including authentic tasks, needs to be fostered more in the course content to provide real world relevance and personal meaning to the learners.

According to Oldfield and Herrington (2012), computers, smartphones, mobile tablets can all be used as cognitive tools. Cognitive tools have been described by Jonassen and Reeves (2004) as “technologies, tangible or intangible, that enhance the cognitive powers of human beings during thinking, problem-solving, and learning” (p. 1) and they are knowledge construction and facilitation tools that can support, guide, and extend the thinking processes of their users (Derry, 1990). As educators and instructional designers, we need to adapt technologies to function as intellectual partners with the learners. Thus, learners can generate deeper information processing results and transfer new information to their own knowledge. The first priority of m-learning or cyber-learning design is to focus on engaging learners in a shared social context for learners to socialize and construct knowledge (Gao, Baylor, & Shen, 2005). Moreover, Viola, Giretti, and Leo (2007) stated that learning will be meaningful and applicable when new information and learning tasks are linked to previous experience and knowledge in the formation of personal and unique understandings. Authentic learning experience and higher order thinking skills are important factors for preparing today’s students to be competitive in a global job market because they must become comfortable with the complexities of ill-defined real-world problem and tasks (Lombardi, 2007). An authentic activity implies real world experiences, which makes the content relevant and engages the learners in their own meaning-making. These activities are achieved through collaboration, simulating situations, and solving relevant scenarios.

Conclusions and future study

The overall conclusion of this study is that the selected iTunes U courses showed some strengths but considerable weaknesses in meeting the instructional design strategies and m-learning framework. Using m-learning platforms to design and deliver courses for learning is a new emerging technology and need to be carefully conferred and assessed from various aspects. Educators argue that mobile technologies can provide a way to engage students (Franklin & Peng, 2008; Hutchison, Beschorner, & Schmidt-Crawford, 2012), promote creativity, and communication. However, the principle we need to keep reminding ourselves to follow is that “the only defensible rationale for making mobile learning part of pedagogy is because it enhances student learning” (Kinash, Brand, & Mathew, 2012).

The following recommendations were provided for educators who are interested in developing an iTunes U course that allows learning flexibility and effective learning experiences to learners at the same time:

- Emphasize instructional strategies that are learner-centered and active, such as blogs or discussion boards, and allow presentations of group work to be shared with classmates.
- Prepare students for their next online session each week during the lesson.
- Develop a Frequently Asked Questions (FAQs) list to aid students in navigating the course content.
- Provide post-tests and quizzes/exams to assess student work.
- Provide authentic and diverse activities for learners to meet their own learning styles.
- Enhance communication and social interaction between learners through blogs or discussion boards to build a friendly online community.
- In terms of learning assessment, evaluation progress could be monitored through formative evaluation, post tests, and quizzes. Frequently asked questions could also make available for student guidance.

Prensky (2001) argued that the ways of students thinking and processing information are totally different compared to their predecessors due to the ubiquitous environment. The features of iTunesU course allow course developers to apply and deliver multi-media formats of content and resources to facilitate learning engagement that meets student needs of different learning styles. An array of applications (apps) and Web 2.0 tools running on mobile devices can be easily commissioned for local use (Melhuish & Falloon, 2010), many of which are suitable for an individual’s learning requirements. Cochran (2014) reviewed longitudinal (2006-2011) participatory action research on mobile Web 2.0 and concluded the following two critical success factors – technological and pedagogical support – and the creation of sustained engagement facilitating ontological shifts for the participants. Instructor can use apps and Web 2.0 tools (i.e., Blogger, Tumblr, Weebly, Skype, Google Group) effectively to develop open and global conversations.
with students and to facilitate learning engagement. If m-learning wants to win a place in future education, this function should be seriously addressed. In regard to future studies, there are needs to explore various instructional strategies and instructional design processes that are applied to design iTunesU courses in different disciplines, and to discover the perceptions of instructors, instructional designers, and administrators on how m-learning management platforms can benefit a student’s learning in the long run.

References


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Job Attainment and Perceived Role Differences of Cyberschool Leaders

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ABSTRACT

As cyberschooling options expand, it is vital that we understand the nuances of these particular learning opportunities. Because little research exists on leaders of K-12 cyberschools, this exploratory case study had two purposes. We first examined how 18 cyberschool leaders in the United States obtained their position. Second, we explored the perceptions of cyberschool leaders regarding the differences between their job and that of a traditional brick-and-mortar school leader. We found that cyberschool leaders tend to be predominantly new, technology savvy administrators who have some background in online learning. Main differences between cyberschool leadership and brick-and-mortar school leadership included interactions with students, teacher supervision, provision of professional development, and management of the day-to-day operations.

Keywords

Cyberschool, K-12 online learning, Principals

Introduction

The importance of school leadership, independent of school setting, is clear (Hargreaves, Moore, Fink, Brayman & White, 2003; Leithwood, Aitken, & Jantzi, 2006). Although we know a great deal about educational leadership within a brick-and-mortar setting, we know very little about school leadership in an online context. Considering the global technological revolution that currently is taking place and the increased availability of K-12 online coursework, online programs, and online schools, it is imperative that we begin to research and understand the differences between leaders of cyberschools (schools that offer fully online programs) and leaders of brick-and-mortar schools. In Education Transformation: How K-12 Online Learning is Bringing the Greatest Change to Education in 100 Years, Packard (2013) discussed the future of education in an online world. Packard noted, “what’s clear today, however, is that a new system of educating children is unfolding, and the journey is far from complete. Although we don’t know the journey’s final destination, it’s nonetheless worthwhile to look a little further down the road” (p. 203). This study offers important insights for understanding how cyberschool leaders were able to move into their positions given the nascent of such career options and how their roles differ from those of brick-and-mortar school leaders. These understandings should help university school administration programs that wish to better address these unique needs and offer context to leaders who want to explore this unique career path.

Research on K-12 online leadership

Beaudoin (2003) suggested that the need for effective leadership is significant in the online world. Abrego and Pankake (2010) articulated that cyberschool leaders cannot operate in an environment of “business as usual” by mirroring leadership practices of brick-and-mortar schools. Some work has been done to investigate how K-12 online programs are led with regard to planning (Berg & Clark, 2005), policy (Augustine-Shaw, 2001; Powell & Barbour, 2011), and funding (Baker & Bathon, 2013). However, a limited number of studies have been dedicated to understanding the explicit roles and needs of the K-12 cyberschool leader. Clark and Berg (2012) indicated that online schools and programs “can play a major role in ensuring equitable access to high-quality learning opportunities for K-12 learners” (p. 11). Of the K-12 online school literature that does exist, very little focuses explicitly on the K-12 cyberschool leader. Thus, the current research is timely and needed.

Research on K-12 online learning often tends to focus on the brick-and-mortar school leader. For example, Karlin (2005) conducted research with the intent to create a handbook for brick-and-mortar school leaders regarding
supplemental K-12 online courses. Additionally, Morse (2010) researched the perceptions of brick-and-mortar school leaders regarding K-12 online learning in the state of Rhode Island. Similarly, Jancek (2003) investigated the participation of Illinois public schools in K-12 online learning. Jancek found that the leaders’ knowledge about technology and virtual learning influences participation rates in supplemental programs.

Some research has been done on how K-12 school leaders evaluate online teachers. For example, Tobin (2004) argued that evaluations of online teaching should be similar, if not the same as, face-to-face teaching because quality instruction transcends its mode. Tobin suggested that the standards of quality education and teaching should not be modified due to the environment in which the learning takes place. In contrast, Saleh and Lamkin (2008) argued that online courses must be evaluated in a different way than face-to-face courses because mode impacts measures of quality. Given the discourse about evaluating teachers and their instruction, Rice (2009) suggested that leaders of K-12 online programs and cyberschools must be strong instructional leaders who need to evaluate course design, improve course delivery, and develop teacher professional development. These skill sets are traditionally developed in pre-service preparatory programs. However, as LaFrance and Beck (2014) found, very few leadership programs give pre-service administrators K-12 online learning field experiences. LaFrance and Beck found that programs that did offer K-12 online learning field experiences were reacting to individual student requests rather than infusing those experiences into the core program.

Brown’s (2009) research focused on principals’ beliefs about the purpose and potential of K-12 online learning. Although now dated, the administrators in Brown’s study indicated that the purpose of online schools is to individualize instruction, expand access, and deliver quality programs. In another study, Quilici and Joki (2011) examined how cyber principals serve as instructional leaders in the organization. Quilici and Joki noted how principals “increasingly find themselves in positions with responsibility for online leadership…how principals meet this new responsibility will determine the online school’s viability in terms of teacher performance and student learning” (p. 143).

Reid, Aqui, and Putney (2009) conducted a case study of the first year of implementation of a cyber high school. The authors suggested that the successful creation of a cyberschool is dependent upon tasks such as developing or acquiring quality online courses, training competent online teachers, and securing adequate funding. These findings are relevant to managing cyberschools even though the focus was not explicitly on the leader.

Researchers have focused on national supplemental programs such as New Zealand’s e-learning clusters that are supported by a national virtual learning network. This program offered classes via videoconferencing and web technologies to high school students. Although not directly focused on the leader, Barbour and Wenmouth (2013) wrote a white paper detailing three possible visions for the structure of these e-learning clusters. The structure of these online programs, however, has direct implications for leadership. For example, Buchanan (2013) focused his Master’s thesis on understanding the leadership structure of the current New Zealand e-cluster and virtual learning network. He found that leaders of these e-learning clusters focused their efforts on pedagogy, ongoing collaboration with stakeholders, dialogue, and creating a shared vision.

Based on the available literature, it is our belief that leadership in cyberschools may differ from leadership in K-12 brick-and-mortar schools. Freedman (2005) noted that K-12 online schooling contributes to a systemic educational transformation “not found in earlier forms of distance education, educational technology, or alternative education” (p. 35). Given the potential for cyberschools, we believe it is imperative that we gain a better understanding of the nuances of this career choice.

**Methodology**

This exploratory collective case study (as defined by Stake, 2000) is focused on the cyberschool leader. We set out to answer two research questions. First, how do individuals become cyberschool leaders? For this question, we were interested in exploring this career path. Second, what perceived differences are there between the roles of a brick-and-mortar school leader versus that of a cyberschool leader? Data collection for the study came from the use of semi-structured, open-ended telephone interviews.
Participants

One of the accrediting bodies for cyberschools is AdvancED. AdvancED (http://www.advanc-ed.org) serves more than 30,000 public and private schools in more than 70 countries. For AdvancED accreditation, online school leaders are charged with meeting five standards that focus on vision, governance, teaching, support, and continuous improvement. In the current study, we used the cyberschools with AdvancED accreditation as our population.

As of early 2013, AdvancED reported accrediting 130 public cyberschools in the United States. Upon further investigation, we found that 32 of those were duplicates, schools within the same school under a different name, or schools that no longer existed. Thus the actual population was 98 public cyberschools. We found the names of school leaders and their contact details through both the AdvancED website and searches of school-specific websites. Recruitment efforts included three rounds of personalized emails sent directly to the 98 school leaders. We followed up with each nonresponsive school leader via a telephone call.

In total 18 school leaders agreed to participate in the study, which achieved an 18.3% participation rate. We considered these 18 participants to be key informants as defined by Patton (1990) since the schools represented a sample that demonstrated a high level of quality given that each was accredited by AdvancED.

Table 1 below details the demographic data of the participants and their respective schools. One third of the interviewees were males. It is uncertain if this represents the norm in the population. Aside from one, all leaders had little to no experience as a brick-and-mortar school administrator. Most \( (n = 14) \) had less than 5 years of experience as a K-12 school leader. The schools in this study represent fully online (school, courses, and programs are fully online) and supplemental (online courses and programs support traditional brick-and-mortar school) public cyberschools.

<table>
<thead>
<tr>
<th>Principal</th>
<th>Gender</th>
<th>State</th>
<th>Experience as brick-and-mortar school administrator</th>
<th>Experience as cyberschool administrator</th>
<th>Type of school</th>
<th>Grade level</th>
<th>Number of students</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Male</td>
<td>Florida</td>
<td>0 years</td>
<td>4 years</td>
<td>Fully online school</td>
<td>K-12</td>
<td>270</td>
</tr>
<tr>
<td>B</td>
<td>Female</td>
<td>Washington</td>
<td>0 years</td>
<td>5 years</td>
<td>Fully online school &amp; supplemental</td>
<td>K-12</td>
<td>451</td>
</tr>
<tr>
<td>C</td>
<td>Female</td>
<td>Colorado</td>
<td>0 years</td>
<td>4 years</td>
<td>Supplemental</td>
<td>9-12</td>
<td>1,200</td>
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<tr>
<td>D</td>
<td>Female</td>
<td>Utah</td>
<td>0 years</td>
<td>4 years</td>
<td>Fully online school</td>
<td>9-12</td>
<td>334</td>
</tr>
<tr>
<td>E</td>
<td>Female</td>
<td>Minnesota</td>
<td>0 years</td>
<td>1 year</td>
<td>Supplemental</td>
<td>9-12</td>
<td>197</td>
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<tr>
<td>F</td>
<td>Female</td>
<td>Utah</td>
<td>0 years</td>
<td>2 months</td>
<td>Supplemental</td>
<td>K-12</td>
<td>456</td>
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<tr>
<td>G</td>
<td>Male</td>
<td>Georgia</td>
<td>0 years</td>
<td>3 years</td>
<td>Supplemental</td>
<td>9-12</td>
<td>8,400</td>
</tr>
<tr>
<td>H</td>
<td>Male</td>
<td>Arizona</td>
<td>0 years</td>
<td>3 months</td>
<td>Fully online school &amp; supplemental</td>
<td>9-12</td>
<td>123</td>
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<tr>
<td>I</td>
<td>Female</td>
<td>Florida</td>
<td>0 years</td>
<td>1 year</td>
<td>Fully online school</td>
<td>K-12</td>
<td>1,589</td>
</tr>
<tr>
<td>J</td>
<td>Female</td>
<td>Oregon</td>
<td>0 years</td>
<td>1 year</td>
<td>Fully online school</td>
<td>K-12</td>
<td>58</td>
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<tr>
<td>K</td>
<td>Female</td>
<td>Utah</td>
<td>0 years</td>
<td>4 years</td>
<td>Supplemental</td>
<td>K-12</td>
<td>1,202</td>
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<tr>
<td>L</td>
<td>Female</td>
<td>Texas</td>
<td>0 years</td>
<td>5 years</td>
<td>Fully online school &amp; supplemental</td>
<td>3-12</td>
<td>5,500</td>
</tr>
<tr>
<td>M</td>
<td>Female</td>
<td>Minnesota</td>
<td>0 years</td>
<td>2 years</td>
<td>Fully online school</td>
<td>K-12</td>
<td>150</td>
</tr>
<tr>
<td>N</td>
<td>Male</td>
<td>Nevada</td>
<td>0 years</td>
<td>1 year</td>
<td>Supplemental</td>
<td>9-12</td>
<td>148</td>
</tr>
<tr>
<td>O</td>
<td>Male</td>
<td>Idaho</td>
<td>2 years</td>
<td>5 years</td>
<td>Supplemental</td>
<td>7-12</td>
<td>3,774</td>
</tr>
<tr>
<td>P</td>
<td>Male</td>
<td>Washington</td>
<td>3 years</td>
<td>8 years</td>
<td>Fully online school</td>
<td>K-12</td>
<td>1,222</td>
</tr>
<tr>
<td>Q</td>
<td>Female</td>
<td>Indiana</td>
<td>8 years</td>
<td>2 years</td>
<td>Supplemental</td>
<td>9-12</td>
<td>13,000</td>
</tr>
<tr>
<td>R</td>
<td>Female</td>
<td>Minnesota</td>
<td>0 years</td>
<td>11 years</td>
<td>Fully online school</td>
<td>8-12</td>
<td>175</td>
</tr>
</tbody>
</table>
Interview protocol

Each participant consented to participate in a 45-60 minute recorded, semi-structured telephone interview. The protocol was developed by modifying interview protocols from previous studies that investigated school technology leadership in different settings (Richardson & McLeod, 2011; Sauers, Richardson, & McLeod, 2014). The interview protocol was shared with participants beforehand.

Limitations

The current research is limited in that the population consisted only of public cyberschool leaders identified by AdvancED. The population is not inclusive of all cyberschool programs (public, private, and charter) in the United States. Our study is also limited by what may be perceived as a relatively small sample. We attempted to interview as many cyberschool leaders as were willing. As such, we invited each of the 98 school leaders to interview. Nevertheless, the data began to reach a high level of saturation through the 18 interviews.

Data analysis

Coding was done using the constant comparative method as detailed by Lincoln and Guba (1986) as well as others (e.g., Patton, 1990). For this study, an initial coding phase was used to develop a robust codebook. A final coding phase was used to code and conduct a confirmatory analysis. For the initial phase of coding, each transcript was coded by one of three researchers using open coding. We worked toward categorical saturation, searching for the “emergence of regularities” (Lincoln & Guba, 1986, p. 350). The researchers collaborated iteratively on the final coding scheme until a consensus was reached.

The final coding phase occurred in three rounds during which each researcher coded a subset of the 18 interviews until every transcript was coded and confirmed. Each transcript thus was coded by one researcher then confirmed or rejected by two different researchers. At the conclusion of each round, inter-rater reliability was calculated. After three rounds we achieved an acceptable agreement rate of 94.7% across three raters. Table 2 below details the inter-rater reliability by round of coding. Using this process, the multiple raters were able to triangulate the data across interviews to find themes (see Merriam, 1998).

<table>
<thead>
<tr>
<th>Round of coding</th>
<th>Number of codes</th>
<th>Number of codes added</th>
<th>Number of codes deleted</th>
<th>Agreement</th>
</tr>
</thead>
<tbody>
<tr>
<td>First</td>
<td>625</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Second</td>
<td>730</td>
<td>105</td>
<td>0</td>
<td>84.5%</td>
</tr>
<tr>
<td>Third</td>
<td>771</td>
<td>41</td>
<td>0</td>
<td>94.7%</td>
</tr>
</tbody>
</table>

Results

The results will be discussed with regards to each of the two research questions. The themes that aligned to each question will be further explored. The themes are not presented in order of importance, but rather by convenience.

Research question 1: How does a person become a cyberschool leader and what core dispositions are needed to be a cyberschool leader?

To better understand how a person secures a cyberschool leadership position, we explored perceptions of core elements of leading a cyberschool as well as these leaders’ past experiences. Themes that arose included being flexible and adaptive, being technology savvy, serving as an instructional leader, and being an effective communicator and collaborator.

Table 2. Inter-rater reliability for each round of coding
Flexible, adaptive, and innovative

Principal R discussed how cyberschool leadership requires being open-minded and innovative. Principal A noted how leading a cyberschool is like traveling to Mars: “It is doing something that no one has done before.” These leaders discussed how change was the norm in cyberschools. “I think that to lead an online school, you have to be progressive and willing to frequently change” (Principal N). Principal L noted how as a cyberschool leader, one must accept that “change is inevitable.” Principal O discussed how change happens much more rapidly in online schools than it does in traditional schools.

Many of the leaders underscored the importance of being flexible, innovative, and change-oriented. For example, Principal A said “neither you nor I can say what cyberschooling is going to look like eighteen months from now.” Likewise, Principal N described how cyberschool leaders need to think outside the box and “look ahead to where the world and society is going to be in the next five years.” Principal R talked about how she secured her current job because the district “needed somebody who would be a little more creative and innovative.”

Technology savvy

The principals in this study detailed how one must have a certain level of technology fluency to be a cyberschool leader. Principal A noted how “leveraging technology is a big part.” This principal discussed how technology literacy is at the core of the role. When asked how they became technology savvy themselves, most of these principals reported that they became familiar with online technologies by taking an online course before they took on the cyberschool leader role. The leaders in the current study each discussed how their vision of leadership revolved around meeting the needs of a digital generation. Principal K described this connection by saying, “I am not afraid of technology and I am also not wowed by people who say they know a lot about technology. I am grounded in the reality that this is all about teaching kids.”

Principal O discussed how her district had preferences for candidates with no school leadership experience but online experience over a candidate with brick-and-mortar school leadership experience and no online experience. When asked how a person can better prepare to take up the role of a cyberschool leader, Principal J said, “one of the first things I would have somebody do is really learn about technology. I think a lot of administrators aren’t familiar with technology or maybe they are prejudiced against it.”

Past experiences of these leaders included a strong background in online or blended learning environments. Principal I stated that she taught online courses and thus “I knew the needs of students in a K-12 online venue and I had a lot of experiences with technology and the things we use on a daily basis to run our school.” Principal O stated that as a principal of a brick-and-mortar school, he “championed a blended learning model before blended learning was a household name.” Principal G did not think it was possible to be a good cyberschool leader unless one had experiences with K-12 online learning. Having strong software, hardware, video, and distance learning experiences were considered useful to getting hired as a cyberschool leader.

Instructional leadership

The leaders discussed how a core element of cyberschool leadership was instructional leadership. Principal Q discussed how a cyberschool leader must “understand that best practices for teaching online are different than teaching in a face-to-face classroom.” Additionally, Principal R reported how cyberschool leaders need to have a strong background in curriculum, standards, and instruction. Principal R described how this skill included monitoring and managing both student and teacher engagement. Principal J articulated that being an instructional leader is harder in an online school. Nevertheless, respondents noted that cyberschool leaders must be adept at building community, fostering teamwork, and getting teachers and students to work together to accomplish learning goals.

Principal F discussed how a cyberschool leader must understand that students in online programs are different than those in brick-and-mortar schools. The leader must understand why students are there and develop programs and experiences to meet their unique needs. Principal O reported that instructional leadership skills are more important than technology skills since the latter can be more easily taught.
Principal Q reported that she was hired because she could translate curriculum and state requirements into an online environment. Principal Q also had strong experiences with conducting and overseeing professional development in a large high school; this was a selling point during her job interview. Principal M believed that she was hired because of her experience as a curriculum director and as a classroom teacher. Principal H talked about how he was hired because of his experience conducting professional development and using instructional models. Principal B discussed how she was hired because of her experiences auditing curriculum and educational programs for five years. Principal I discussed how she was hired because she was a project manager in the business world and had expertise in innovative approaches to curriculum development. Experiences that help one become an instructional leader (e.g., curriculum, professional development, and standards) appear to be important to secure a job as a cyberschool leader.

*Communication and collaboration*

The cyberschool leaders in this study discussed that a core element to their leadership was communicating and collaborating with others. Principal D noted that she “would couple collaboration and communication” as a vital element of running a cyberschool. Leaders discussed how communication with students, teachers, and parents had to be regular and well thought out. Equally so, these leaders emphasized clarity of writing and message design. For example, Principal Q talked about how her “writing must be much more precise and accurate” given that most communication is done online.

Setting a vision is vital. However, communicating that vision is even more important. Principal K discussed how vision is as important in a cyberschool as it is in a brick-and-mortar school. However, a cyberschool leader must think plan for potential population growth of student and teacher. Principal E discussed how she secured the leadership position in her school because she was able to communicate the school’s vision to stakeholders - unlike the previous leader. Principal J discussed how the online school leader must be collaborative and proactive.

Principal D discussed the importance of collaborating with peers. She mentioned that she was hired “because I know how to play the game.” She talked about hiring the right people with whom she could collaborate. Her experiences of owning a lawn care business and learning how to deal with customers also played a major role in her getting hired. Principal K noted that she was hired because she had a well-articulated vision for the cyberschool. Further, she had “developed personal networks of people that she could turn to” as she led the cyberschool initiative. Principal F was hired because of her background in communications and marketing. Principal E noted that she was hired to start the school, so her ability to build rapport with staff was absolutely necessary. She was hired to “speak to a larger community...and craft a message and a strategy for reaching out.”

**Research question 2: What differences are there between brick-and-mortar school leaders and cyberschool leaders?**

The leaders in the current study were asked whether the job of a cyberschool leader was different than that of a brick-and-mortar school leader (asked as an open ended question). They then were asked to explain those differences. We followed up this question with asking if they agreed or disagreed with categories that appeared in other interviews. Table 3 below details the percentage of leaders who reported that leadership responsibilities were indeed different for a cyberschool leader. Note that some leaders did not choose yes or no for each difference.

Interacting with students, supervising teachers, providing professional development, and managing day-to-day operations were factors noted to be different by the highest percentage of cyberschool leaders in the study. The lowest percentage (41.2%) reported that legal and ethical issues were different. This is the only category where more leaders (n = 10) reported that this was not a difference. For the sake of brevity, what follows is a discussion of each of the four main topics, supported by quotes from selected cyberschool leaders in the study.
Table 3. Cyberschool leaders who reported differences by topic

<table>
<thead>
<tr>
<th>Theme</th>
<th>Yes</th>
<th>No</th>
<th>%*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interacting with students</td>
<td>17</td>
<td>1</td>
<td>94.4%</td>
</tr>
<tr>
<td>Teacher supervision</td>
<td>15</td>
<td>1</td>
<td>93.6%</td>
</tr>
<tr>
<td>Providing professional development</td>
<td>15</td>
<td>2</td>
<td>88.2%</td>
</tr>
<tr>
<td>Managing day-to-day operations</td>
<td>15</td>
<td>2</td>
<td>88.2%</td>
</tr>
<tr>
<td>Policy and/or political advocacy</td>
<td>13</td>
<td>2</td>
<td>86.7%</td>
</tr>
<tr>
<td>Curriculum development</td>
<td>13</td>
<td>2</td>
<td>85.7%</td>
</tr>
<tr>
<td>High quality instruction</td>
<td>14</td>
<td>3</td>
<td>82.4%</td>
</tr>
<tr>
<td>Recruiting and hiring</td>
<td>13</td>
<td>4</td>
<td>75.6%</td>
</tr>
<tr>
<td>Interacting with parents</td>
<td>13</td>
<td>4</td>
<td>76.5%</td>
</tr>
<tr>
<td>Budgets</td>
<td>12</td>
<td>5</td>
<td>70.6%</td>
</tr>
<tr>
<td>Legal and ethical issues</td>
<td>7</td>
<td>10</td>
<td>41.2%</td>
</tr>
</tbody>
</table>

Note. *The percentage represents those principals who discussed the topic and reported the topic was different.

Interacting with students

Over 94% of the cyberschool leaders discussed how interacting with students was different in an online environment. Leaders discussed how discipline was different in an online environment in contrast to a face-to-face environment. Principal D said, “We do have cyberbullying. These cute little teenage boys get online and see these cute little teenage girls and it’s just a whole different ball of wax in the digital environment.”

Regarding student interactions, cyberschool leaders also reported that the quality of communication and the types of discussions were different in an online environment. The leaders discussed how online communication resulted in better student interaction and a higher level of engagement. Cyberschool principals discussed how not relying on visual cues actually increased quantity and quality of their written communication.

Teacher supervision

Many of the cyberschool principals talked about teacher supervision and evaluation. Fifteen of the principals reported that this task was different for a cyberschool leader. However, they also noted how being online made this part of their job easier. Instructional leadership was discussed primarily in terms of being able to take a more in-depth approach to teacher evaluation compared to brick-and-mortar leaders. Leaders reported spending time supervising, evaluating, and using data to gather information on teacher performance across a longer period of time. The leaders discussed how the use of a learning management system allowed them to see what teachers were doing, either at present or in the past. The technology allowed them to gather a wider range of data. This robust data included almost all communications with students, lessons taught, student assignments submitted, and teacher-to-student feedback. As Principal Q put it, “there’s a virtual footprint for every teacher that I can observe.”

An additional topic noted by many of the leaders was how technology provided a more focused learning environment. It was discussed how this environment is free of distractions normally experienced by brick-and-mortar principals such as attending sporting events. As noted above, the technology also gave these leaders a greater access to observational and statistical data on teachers’ practices. The ability to monitor resulted in a more comprehensive system of teacher supervision and evaluation. For example, it was discussed how the use of a learning management system allowed the principal the opportunity to observe all student interactions, not just those witnessed in a fixed physical observation. Additionally, recordings of lessons, activities, and grading afforded these leaders the opportunity to observe various aspects of the learning experiences.

Providing professional development for teachers

Participants discussed how providing professional development for teachers was different when leading a cyberschool. Leaders discussed how professional development for teachers in a cyberschool is more individualized,
sometimes blended, and often conducted in a community of practice. For example, Principal O talked about individualized professional development.

We are also able to really differentiate the professional development that we offer for our teachers. So it is not a one-size-fits-all professional development model. We can track teachers where they are in terms of their growth and their confidence and provide targeted professional development based on where those are. In traditional environments you are often provided professional development kind of holistically for a group around certain themes or whatever the case may be.

Individualized professional development was also noted to be the product of the communication channels available through the use of learning management systems, text messaging, and video conferencing.

Cyberschool principals also discussed using a blended model of professional development. This allowed leaders to meet teachers’ professional development needs in a combination of face-to-face and online contexts. This mixture gave teachers the advantage of face-to-face collaboration with other teachers while allowing for online, individualized professional development to address personal needs.

Four principals discussed the importance of integrating professional development into curriculum development in order to select the best combinations of content, pedagogical methods, and delivery. For example, Principal D stated, We have more control over a greater number of variables in the instructional arena...we have these thirty teachers that are basically incubators of innovation and when they find something that works they bring it to us, we put it on the faculty meeting schedule, and they present a workshop on what they figured out, how it works, the data to support it, the evidence that they have that it’s successful....You can just watch the entire room as they are figuring out how to implement it in their classroom.

Additionally, cyberschool principals in this study discussed how peer mentoring and data driven interventions were easier to implement in an online environment.

Managing day-to-day operations

Fifteen principals indicated that managing day-to-day operations in a cyberschool was different for them than colleagues in brick-and-mortar schools. Participants discussed how a cyberschool leader has more opportunities to adhere to daily and long-term plans. This increased focus was due to both a lessening of common duties assigned to a brick-and-mortar leader (e.g., student discipline, hall monitoring, bus duties) and an increased need to keep on top of educational technology advances.

The cyberschool leaders indicated that technology afforded them unique opportunities when it comes to managing a school. Principal C said, I think online is still a lot more data-driven in terms of the day-to-day operations. My primary goal on a daily basis is pulling data, looking at data, and figuring out exactly what’s happening with each student, what is happening with each of my teachers, and making sure that the right messages are going out...I think we can do that because of the technology within our learning management system and our student information systems. We are further along into that idea of having ongoing and predictive analytics for our students that we can use to manage engagement that aren’t in place in a lot of traditional [schools].

A small number of cyberschool leaders discussed funding differences in a cyberschool versus brick-and-mortar school. With regards to funding, Principal L said, “We get less funding than the brick-and-mortar schools do. We can’t provide as many resources maybe as other schools.” Likewise, Principal G noted how “resources is another piece. We try to build all of our textbook so we are not having to worry about sending materials to a large number of students.” These costs however cannot always be avoided. Principal P talked about Advanced Placement classes. “In those classes we do have to provide a text. [Additionally,] lab equipment is more difficult for us because we have to purchase that and ship it” to students. Principal P detailed how his cyberschool only gets “80% of full funding so we operated at a loss for two years and our district had to supplement us to a tune of about a half million dollars for the last two years.”
Discussion and conclusions

Authors have called for more research on the practice of K-12 online education generally and cyberschools specifically (Cavanaugh, Barbour, & Clark, 2009). Additionally, authors have urged researchers to focus on student learning in these environments (Barbour & Hill, 2011; Smith, Clark, & Blomeyer, 2005). There has been valuable work done investigating brick and mortar principals’ perceptions of cyberschools (Brown, 2009; Karlin, 2005), but little has been done to explore the actual experiences of leaders of cyberschools (McLeod & Richardson, 2014). The current research aimed to be a foundation that can address this need.

This study was developed to explore two lines of inquiry. First we explored experiences that impacted a cyberschool leader’s choice to accept this challenging position. Given that cyberschool leadership is a relatively new field, there are few data or leadership norms to inform practice. As a result, potential leaders of cyberschools may be unaware of the required skills set and thus may be ill-prepared for this job role. We identified four common themes from participants’ interview responses. These skills are directly linked to being innovative leaders who must attend to the unique learning needs of teachers and students.

First, cyberschool leaders must be flexible and adaptable. This need has been noted in brick-and-mortar schools as well (Duke, 2004). Being adaptable to the changing needs of a cyberschool (be it technological, pedagogical, human resources, or cultural) requires a leader who does not shy away from change. Participants discussed how cyberschools are in their infancy and thus a constant state of change is the norm.

Second, cyberschool leaders need some degree of technology savviness. Leaders reported that it would be very difficult to lead an online school or online program without having a core understanding of what online learning was like from an end-user perspective. Having past experiences as either a teacher or a student in an online course appeared to be an essential experience. Being a technology savvy leader in a cyberschool thus looks different than it does in a brick-and-mortar school. For example, Sauers, Richardson, and McLeod (2014) found that effective school technology leaders need not be technology-savvy themselves, but rather can understand the tenets of technology leadership and surround themselves with the right people. In cyberschools however, it appears that being tech savvy is part of the job requirement.

Third, instructional leadership skills were vital to cyberschool leadership. This adds to the literature body given that Neumerski (2012) recently called for more work on contextual factors of instructional leadership. Like their brick-and-mortar school leader counterparts, a cyberschool leader must have a strong understanding of curriculum, standards, and instruction but must filter those through the particular lens of online learning. Instructional leadership has long been discussed as a core practice of brick-and-mortar leaders (see Leithwood & Jantzi, 2005; Marks & Printy, 2003).

Fourth, cyberschool leaders need to be good communicators and collaborators. These skills have been noted brick-and-mortar school leaders as well (Arneson, 2011; Dotger, 2011). However, given that most interactions by cyberschool leaders are done electronically, it is essential that these leaders master the skills of written communication and message design. Thus the context of the virtual environment makes this skill more important and nuanced.

The second line of inquiry focused on how cyberschool leaders perceived their job to be different than that of a brick-and-mortar school leader. In this study, four key differences between leading a cyberschool and leading a brick and mortar school were explored. These differences included interacting with students, teacher supervision, providing professional development, and managing day-to-day operations. These elements are vital in a brick-and-mortar school, however the nature of a cyberschool requires these leaders to act on these tasks differently. Some of these issues have also been suggested by Berg and Clark (2005) who noted that cyberschool leaders need to understand stakeholder needs, assess readiness, and create a vision of learning. Further, these findings mirror those of Buchanan (2013) who found that leaders of K-12 online programs tend to focus on ongoing collaboration with stakeholders, dialogue, and creating a shared vision for the organization.

Woven throughout the perceived differences between cyberschool leadership and brick-and-mortar school leadership is the notion that technology can transform how leaders interact with students; how leaders evaluate, supervise, and professionally develop their teachers; and how leaders operate on a day-to-day basis. As evidenced by the
cyberschool leaders in this study, technology can be used to focus on instructional leadership in their day-to-day operations in ways that are not easily afforded in brick-and-mortar environments. Technology enabled these cyberschool leaders to gain a comprehensive and contextual picture of the growth and needs of their instructors and students. The leaders of cyberschools discussed being able to provide customized, just-in-time feedback that teachers can implement immediately. This is perhaps the most transferable of all of the lessons learned by these cyberschool leaders. As digital technology becomes increasingly ubiquitous in schools, leaders need to find better ways to utilize them as mechanisms to increase instructional quality. A data-driven system that helps to evaluate and remediate teachers in real-time could make a significant difference in providing formative evaluation that is meaningful and relevant to teachers.

This study illuminates the need for more research on cyberschool leadership. Potential future research studies include: investigating motivators for pursuing this career path; how leaders are chosen from the hiring agents’ perspective; whether the roles were filled by appointment, volunteering, or external formal candidate search; and whether those with non-cyber experience prefer being a cyber leader or a brick-and-mortar leader. The field of educational leadership is greatly served by better understanding this career path and those leaders who opt to embark upon this journey. Given that this field is burgeoning and rapidly changing, it is imperative that we remain current on its needs.

The current study confirms what other authors have found regarding innovation and technology. First, a technology mindset might be best facilitated in pre-service leadership preparation programs (LaFrance & Beck, 2014; McLeod, Bathon, & Richardson, 2011). In short, leadership preparation programs are not preparing leaders to lead innovative models of schooling such as cyberschools. Based on the literature, our experiences in educational leadership programs, and the findings from this study, it is evident that pre-service educational leadership programs are not meeting the needs of modern, digitally infused schools, especially cyberschools. By better understanding this nascent field, university preparation programs can create learning experiences that prepare both brick-and-mortar school leaders as well as cyberschool leaders. University leadership programs can address the needs of the field by incorporating online learning experiences into the curriculum, mandating cyberschool internships, and focusing on differences leaders will experience if they pursue a cyberschool leadership position.

References


Development and Effectiveness Analysis of a Personalized Ubiquitous Multi-Device Certification Tutoring System Based on Bloom’s Taxonomy of Educational Objectives

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ABSTRACT

In recent years, with the gradual increase in the importance of professional certificates, improvement in certification tutoring systems has become more important. In this study, we have developed a personalized ubiquitous multi-device certification tutoring system (PUMDCTS) based on “Bloom’s Taxonomy of Educational Objectives,” and applied it to help students obtain HTML certificates. The system can help students learn more effectively and acquire certificates more successfully through the mechanism of personalized strengthening practice and the function of the learning diagnostic light table. The experimental results show that, compared with the control group, the experimental group has significantly better cognitive test scores. Meanwhile, from the interviews, it was also found that the students generally believed that the multi-device design makes it more convenient for them to use the system, and the learning diagnostic light table can make them more aware of their learning status.

Keywords

Personalized learning, Ubiquitous learning, Multi-device learning system, Certification tutoring system, Bloom’s Taxonomy of educational objectives

Introduction

With the trend of the information industry moving towards professionalization, enterprises are paying attention to their employees’ individual professional competence much more than to their academic qualifications (Kerckhoff & Bell, 1998). Shanker (1996) argues that the certification authentication mechanism can ensure the skills and knowledge required in the professional field. Xiao (1993) further pointed out that professional certification not only consists of the basic certificate to prove professional competence, but also affects enterprises’ hiring decisions. In recent years, in order to enhance students’ professional capacity and competitiveness in the job market, many universities have started offering certification tutoring courses, and actively promoting students’ attainment of certificates. Therefore, how to develop a more efficient way to enhance students’ certification exam pass rates is a very important issue.

In recent years, e-learning (electronic learning) has become increasingly popular. In order to maximize the benefits of e-learning, the most important issue is to fully understand students’ personal characteristics and learning styles, and then provide appropriate assessment designs. In the past, many researchers used assessment methods to help learners more clearly understand the deficiencies in their learning and to give them appropriate assistance (Perkowitz & Etzioni, 1997; Wang, 2011; Wang, 2008).

Bloom, Engelahar, Frust, Hill and Krathwohl (1956) proposed “Bloom’s Taxonomy of Educational Objectives,” which is widely used by educators, and was later expanded into a new version (Anderson & Krathwohl, 2001). There are many precedents, for example, Shen et al. (2005), to use it as a basis for developing an adaptive assessment system. However, most of these applications are still limited to the use of computers. In recent years, with the advances and popularity of information technologies, wireless networks and mobile devices, most students now own mobile devices such as smartphones and tablet PCs. These devices are portable and can be connected to the Internet. They allow students to be able to learn outside of class time. Chen, Kao and Sheu (2003) pointed out that mobile devices have the advantages of immediacy and convenience. Therefore, this study used a dynamic web technology to...
construct a multi-device certification tutoring system. Through connecting the Internet or a wireless network to the system, students can use various mobile devices (smartphones, tablet PCs, notebooks) to implement ubiquitous learning.

In this study, we developed a personalized ubiquitous multi-device certification tutoring system (PUMDCTS) based on “Bloom’s Taxonomy of Educational Objectives” and applied it to help students obtain the HTML certificate. After the students finish the online tests, the system will provide a Bloom capability indicator so that they can know their learning status. In addition, according to the students’ weaknesses, the system provides strengthening practice by adding weight when assigning test questions. We hope that the certification exam pass rate of students can be improved through this system. Finally, we also designed an experiment to explore the effectiveness of using the system. Compared with the traditional computerized certification tutoring system, the learning effectiveness as a result of using PUMDCTS was enhanced. In addition, we also interviewed students to elicit their views on PUMDCTS.

**Literature review**

**Development and trends of certification tutoring systems**

With the increasing importance of certification, many researchers have started improving and researching certification tutoring systems. For example, Hwang, Chen, and Wang (2012) imported the technology of the interactive multimedia e-books into their certification tutoring system. Xie, Hwang, Bai, Lin and Tseng (2012) combined QR Codes (Quick Response Codes) with their certification tutoring system to implement mobile-learning. They pasted the corresponding QR Code of the detailed explanation of the answer of the test question on textbooks so that students could learn more easily. Hwang, Lee and Tseng (2012) added some game elements to their certification tutoring system. The results indicated that their enjoyable game-based system may be more helpful than the traditional version for those participants with lower prior knowledge and who exerted a lower degree of effort. Hwang, Chuang, Chen and Tseng (2012) further combined a customized interface with their certification tutoring system. The system allows students to learn by using different technology devices, and to choose their needs by setting customized menu buttons.

In the past, certification tutoring systems were only used on computers. They have gradually been evolving to provide diversification and mobility. However, there is as yet very little related research on personalized ubiquitous multi-device certification tutoring systems. The focus of our study is therefore on how to enable learners to use a certification tutoring system anytime and anywhere, while also helping enhance their understanding of their own learning status.

**Bloom’s taxonomy of educational objectives**

The assessment results of a system must be able to clearly reflect the teaching objectives so that appropriate assistance can be provided based on the individual status of students. In the analysis of teaching objectives, the most appropriate reference is Bloom’s Taxonomy of Educational Objectives (Chen & Wu, 2003).

Bloom et al. (1956) proposed “Bloom’s Taxonomy of Educational Objectives” (herein referred to as the old version) in 1956. The educational objectives were divided into two parts: “knowledge” and “intellectual abilities and skills.” “Knowledge” constitutes a single category, while “intellectual abilities and skills” is divided into five categories. Thus, there are six categories in all. Sorted from simple to complex, they are knowledge, comprehension, application, analysis, synthesis and evaluation. This taxonomy was adopted by many scholars for a considerable period of time. However, over time, it was found that some parts needed improvement. Thus, Anderson and Krathwohl (2001) proposed a revised edition of “Bloom’s Taxonomy of Educational Objectives” (herein referred to as the new version). They divided the original educational objectives into the “knowledge dimension” and the “cognitive process dimension.” The “knowledge dimension” is a category of knowledge, including factual
knowledge, conceptual knowledge, procedural knowledge and metacognitive knowledge. The “cognitive process dimension” is divided into six categories: remember, understand, apply, analyze, evaluate and create.

Applying Bloom’s Taxonomy of Educational Objectives to evaluate learning effectiveness can not only reflect the learners’ learning effectiveness, but can also give educators clear guidance (Shen et al., 2005). For example, Wu, Hwang, and Tsai (2013) proposed an expert system which adopts several cognitive processes in Bloom’s taxonomy of educational objectives. The results showed that the experimental group students had significantly better achievements than the control group students in the “remember,” “apply,” “analyze,” and “evaluate” categories, while no significant difference was found in the “understand” category. In this study, we applied Bloom’s Taxonomy of Educational Objectives to implement a Bloom light table to diagnose students’ learning status.

**Personalized learning**

Chen and Macredie (2010) proposed that there are three human factors which may affect learners’ learning effectiveness. In other words, differences in individual prior knowledge, cognitive style and gender may result in different learning outcomes. According to an individual’s status, different teaching methods are utilized. This type of learning method is called personalized learning. In the past, many studies were developed related to personalized learning. For example, Wang, Tsai, Lee, and Chiu (2007) proposed a personalized learning object recommendation model. From their experimental results, it was found that the model is efficient in terms of making adaptive personalized learning object recommendations. In addition, Nedungadi and Raman (2012) also proposed a cloud-based adaptive learning system which incorporated mobile devices into a classroom setting. The system was used in school computer labs. It provided teachers with real-time feedback on individual and group learners, and pedagogical recommendations for content adaptation based on the users’ knowledge levels and preferences. In general, the main emphasis of personalized learning is that the appropriate teaching content is provided according to the learner’s knowledge level, learning experience, learning needs, and other personal factors. Based on learners’ individual differences, the learning materials should be adjusted (Cho, Kim, & Kim, 2002).

Egan (1999) pointed out that images can make the message more specific. For example, Chen, Chen and Chen (2011) also proposed a color-oriented tool to trace students’ learning processes. From the different colors, teachers can quickly notice those students with poor performance in the learning process.

Taking these developments into consideration, this study built a system to enable students to more clearly view their learning status. We designed a Bloom light table to diagnose students’ weaknesses. Using this table, a mechanism to strengthen the practice of exam questions can be implemented. The system also displayed lights of different colors at the end of the exam so that the students could see their level for different chapters. In this way, the aim of personalized learning can be achieved.

**Ubiquitous learning**

In recent years, with the popularity of wireless network technologies and mobile devices, learning activities are no longer limited by time and space. Whenever learners go outside, no matter where they are, digital learning activities can be conducted. This forms a ubiquitous learning environment (Hwang, Tsai, & Yang, 2008; Hwang, Wu, & Chen, 2007).

Hwang, Wu, Tseng and Huang (2011) built a context aware ubiquitous learning platform from which students can get an instant reply when they meet problems in the learning process by connecting the mobile devices to the platform. The experimental results show that students’ achievement and efficiency were significantly improved.

In this study, in order to enable students to absorb knowledge more freely and actively, the certification tutoring system was built using a cloud database. Students can use their mobile devices or PCs (personal computers) to link to the system anytime and anywhere. Thus, ubiquitous learning can be conducted.
The related applications of multi-device learning systems

In recent years, with the rapid development of mobile learning, the learning modes have changed greatly. Learning can not only be performed using computers but also with mobile devices such as smartphones, tablet PCs, notebooks and digital personal assistants (PDAs), to conduct ubiquitous learning (Lin, Chu, Wang, & Guo, 2012).

However, the diversity of mobile learning devices results in compatibility issues. The specifications of different devices are not the same. This can limit the functionality of software when its design does not consider the individual characteristics of mobile learning devices. Hwang, Chuang, Chen and Tseng (2012) proposed a game-based learning system and integrated the diverse mobile learning devices. This system can detect the learners’ device type and then adjust to a more suitable device layout. Users can also set menus based on personal needs. The mechanism can implement the integration of multiple devices.

Multi-device designs not only facilitate learning but also reduce system development costs. We believe that this concept will be of increasing interest. Therefore, in this study, to make the certification tutoring system more convenient for students to learn, we provided a multi-device environment for them to practice certification exam questions.

The architecture and functions of PUMDCTS

Students can use PCs and mobile devices, such as smartphones, tablet PCs and notebooks, to connect to the server through the Internet or wireless networks. Subsequently, they can log into the system by inputting their student ID and password to conduct the practice of exam questions, mock exams and individual score inquiries. Teachers can use PCs and the Internet to manage all the system databases. The hardware architecture of the system is illustrated in Figure 1.

The system development tools include ASP.NET for the web page design and SQL server for the database management. Students can conduct the practice of different chapters through the “exam practice module,” take similar exams to the real certification exam through the “mock exam module,” and conduct individual score inquiries to know all their scores through the “score inquiry module.” Teachers can manage students’ data, scores and portfolios by using the “student data management module,” the “student score management module,” and the
“student portfolio management module.” Teachers can also manage exam questions through the “exam question management module.” The software architecture of the system is illustrated in Figure 2.

In addition, we designed a ranking table of exam experience on the login screen. This table was ranked according to the total number of questions answered correctly by students. We expected that healthy competition would enhance the students’ learning motivation.

The classification of certification exam questions

According to the new version of Bloom’s Taxonomy of Educational Objectives, the cognitive process dimension has six categories. They are “remember,” “understand,” “apply,” “analyze,” “evaluate” and “create.” The course of certification tutoring is HTML and the certification exam is TQC HTML 4.01 for which the exam questions are multiple choice questions, so only the first four categories were used to evaluate the students’ HTML capability. As regards the categories of “evaluate” and “create,” deeper evaluation standards such as project implementation need to be defined. However, because the course focuses on acquiring the certificate and building basic knowledge, PUMDCTS uses only “remember,” “understand,” “apply” and “analyze.” In addition, because most of the exam questions of the TQC HTML 4.01 Item Bank are synthetic, it is more appropriate to simply divide the questions into two levels by combining “remember” and “understand” into a low level and “apply” and “analyze” into a high level. The exam questions consisted of 500 questions distributed throughout nine chapters. To judge what level each exam question belonged to, we invited two teachers who had more than five years of experience teaching HTML courses. Based on their teaching experience, the teachers divided the 500 questions into two levels. If a question belonged to “remember” or “understand,” it was allocated to the low level, while those questions belonging to “apply” or “analyze” were categorized as the high level. After classification, the data were input into the exam question database.
to facilitate the implementation of the subsequent personalized strengthening practice mechanism and learning status diagnosis.

**Learning diagnostic mechanism**

After students finish the exam practice, the system will calculate the rates of correct answers for the low-level and high-level questions respectively, and display the Bloom light table. The light color depends on the rate of correct answers. If it is greater than or equal to 70%, the light is green, if it is less than 70% but greater than 40%, it is yellow, and if the rate is less than or equal to 40%, the light is red. An example is illustrated in Table 1. When a student has completed 10 questions of a certain chapter, the system will judge whether the answers are correct or incorrect and calculate the rate of correct answers. In the example, because there are five questions for the low level of which three are answered correctly, the rate is 60% and the light is yellow. For the high level, the rate of correct answers is 20% and the light is red. If a student finishes the practice of every chapter of exam questions, he/she will have a table showing 18 lights.

<table>
<thead>
<tr>
<th>Level</th>
<th>Correct/Total</th>
<th>Correct rate</th>
<th>Light colors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low-level (remember and understand)</td>
<td>3/5</td>
<td>60%</td>
<td>Yellow</td>
</tr>
<tr>
<td>High-level (apply and analyze)</td>
<td>1/5</td>
<td>20%</td>
<td>Red</td>
</tr>
</tbody>
</table>

**Strengthening practice mechanism**

Figure 3 shows the algorithm to pick exam questions so that the students’ weaknesses can be improved by practicing more frequently.

In order to achieve the purpose, a random number R between 1 and 100 is generated for picking an exam question. If R is between 1 and 50 then the pick will enter the “strengthening area.” If R is between 51 and 100 then the pick will enter the “general area.” If the pick procedure enters into the “strengthening area,” the system will read the exam questions for which the Bloom light is red and randomly pick an exam question from those questions. The red light area represents that the exam questions have a high error rate, so the mechanism may result in a greater chance (50%) of picking those questions to allow the student more practice with those questions.

If the pick procedure enters into the “general area,” a random number R2 between 1 and 100 is generated. If R2 is between 1 and 50 then the pick will enter the “white light area.” The white light area represents that the exam
questions have not yet been picked and those questions should have a higher chance (50%) of being picked. If R2 is between 51 and 80 then the pick will enter the “yellow light area.” The yellow light area represents that the exam questions have a middle error rate and so those questions will have a middle chance (30%) of being picked. If R2 is between 81 and 100 then the pick will enter the “green light area.” The green light area represents that the exam questions have a low error rate and thus will have a low chance (20%) of being selected.

If no questions exist in the “strengthening area” (red light area), then R will be changed to between 51 and 100. Thus, the system will be forced into the “general area.” If no questions exist in the “white light area,” then R2 will be changed to between 51 and 100. Thus, the system will be forced into the “yellow light area” or the “green light area.” If no questions exist in the “yellow light area,” then R2 will be changed to between 81 and 100. Thus, the system will be forced into the “green light area.”

The main functions of each module for the student interface

To improve students’ weaknesses, we implement the strengthening practice mechanism through the exam practice module, which allows students to practice the exam questions. Freedom is also provided to allow the students to choose a range for the exam, but each practice is limited to a maximum of three chapters. After the students have finished practicing, the system shows them the Bloom light table for the range.

The mock exam module is to simulate a real certification exam situation, and therefore does not invoke the strengthening practice algorithm. The questions are picked randomly from all nine chapters of the exam question base, and the exam time is limited. The system will also show the Bloom light table at the end of the mock exam.

The main differences between the two modules are as follows:

- The exam practice module lets students choose the chapters to be tested, while the mock exam module does not.
- The exam practice has no time limit, while the mock exam is limited to 40 minutes, which is the same as the real certification exam.
- The exam practice module shows only the lights of the chosen chapters, while the mock exam module shows comprehensive lights.
- The exam practice module will pick those questions which should be strengthened according to the student’s weaknesses, while the mock exam module picks the questions completely randomly.

At the end of every exam, the students can enter the result inquiry module to browse all their exam scores and Bloom light tables.

The main functions of each module for the teacher interface

Teachers can manage the basic data for each student, such as student ID, name, etc., by using the “student data management module.” The teachers can manage the students’ scores for each exam by using the “student score management module.” The teachers can manage the students’ portfolios, which record the data of the processes when students take exams and make score inquiries, by using the “student portfolio management module.” The teachers can append, update, delete and inquire about the exam questions through the “exam question management module.”

Snapshots of the system execution

Figure 4 is a snapshot of a mock exam on a smartphone. The snapshot shows that, after finishing the mock exam, the system will give the test score and the comprehensive Bloom light table. Because the screen size of the smartphone is small, the information which can be accommodated is limited. Thus, a streamlined design layout is needed. Therefore, we integrated some functions into a menu button. The functions of the button contain “test again,” “navigation of the questions” and “back to home page.” Figure 5 is a snapshot of a practice exam on a tablet PC. Students are free to choose up to three chapters to test, and the system will give the test score and the Bloom light table of the test range. Because the screen size of tablet PCs is smaller than that of PCs, the layout is adjusted
specifically. Figure 6 is a snapshot of a PC while a student is conducting a mock exam. Due to the large screen size of PCs, the layout is designed to accommodate more information.

Figure 4. Snapshot of a mock exam on a smartphone

Figure 5. Snapshot of a practice exam on a tablet PC

Figure 6. Snapshot of an exam process on a PC
Research method

In this study, we planned an experiment to investigate the effectiveness of the system. The participants were 94 sophomore students at a University of Science and Technology in the central region of Taiwan. The experimental course was HTML. We divided the students into an experimental group and a control group in a random manner. Each group consisted of 47 students. Before the experiment, the first quiz was conducted and regarded as the pretest. In addition, the course teacher and the progress of the course for the two groups were identical.

The experimental group used PUMDCTS and the control group used the general certification tutoring system which picks exam questions at random. The experimental process matched the progress of the HTML course. During the three lessons each week, the last was fixed to practice questions with the two systems. The systems were open around the clock, and the students were free to use them whenever they wanted. The duration of the experiment was one semester, with a total time of four months.

The experimental process of this study was divided into two stages. The first stage was the learning effectiveness analysis. This stage analyzed the test scores of the midterm exam, the second quiz between the midterm exam and the final exam, and the final exam within one semester. Each test was divided into 2 parts: the cognitive test and the technical test. The cognitive test consisted of multiple choice questions. The number of exam questions and time limits were consistent with the formal certification exam. A total of 50 questions were picked from chapters of a certain range, and the exam time was 40 minutes. The technical test was conducted using a PC to implement the requested functions in the exam questions. There were 10 questions in the technical test. The score was distributed into the two parts for which the cognitive test constituted 50 points and the technical test 50 points. This stage was to analyze the differences in the achievements of the two groups in the cognitive test and the technical test when using the systems. The flowchart of the first stage is shown in Figure 7.

The second stage involved in-depth interviews after the end of the experiment. A questionnaire of open-ended questions was designed to collect more in-depth views of the participants on PUMDCTS. In addition, we chose 23 students for in-depth interviews, mainly to understand their views on the usefulness of the system, the ease of use of the system, and the help the system provided them with learning. We expected that a wide range of data could be collected and analyzed to make the results more complete.
Experimental results and discussions

The results of the first stage - the learning effectiveness of the cognitive tests

This section analyzes the cognitive test scores of the pre-test and the three post-tests (i.e., midterm exam, second quiz and final exam) to show the effectiveness of PUMDCTS and the continuity of the effect. To more precisely evaluate the two groups’ learning performances, ANCOVA was used to compare their cognitive test scores in the midterm exam, second quiz and final exam by excluding the impact of the pre-test scores.

Before employing ANCOVA, the homogeneity of the regression coefficient was tested and confirmed with $F = 2.56$ ($p > .05$), implying that ANCOVA can be applied to the analysis of the three post-test scores of the two groups.

Table 2 shows the ANCOVA results. It was found that the students who learned with PUMDCTS showed significantly better cognitive test scores than those who learned with the traditional certification tutoring system in the three post-tests with $F = 11.473$ ($p < 0.01$), $F = 5.435$ ($p < 0.05$) and $F = 11.106$ ($p < 0.01$), respectively. That is, the effectiveness of learning with PUMDCTS lasted until the final exam.

Table 2. ANCOVA results of the two groups’ cognitive test scores in the midterm exam, second quiz and final exam

<table>
<thead>
<tr>
<th>Variables</th>
<th>Experimental group</th>
<th>Control group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Midterm exam</td>
<td>N=47</td>
<td>N=47</td>
</tr>
<tr>
<td></td>
<td>Mean</td>
<td>Mean</td>
</tr>
<tr>
<td></td>
<td>31.64</td>
<td>26.79</td>
</tr>
<tr>
<td></td>
<td>SD</td>
<td>11.711</td>
</tr>
<tr>
<td></td>
<td>Adjusted mean</td>
<td></td>
</tr>
<tr>
<td></td>
<td>32.176</td>
<td>26.250</td>
</tr>
<tr>
<td></td>
<td>$F$</td>
<td></td>
</tr>
<tr>
<td></td>
<td>11.473***</td>
<td></td>
</tr>
<tr>
<td>Second quiz</td>
<td>Experimental group</td>
<td>N=47</td>
</tr>
<tr>
<td></td>
<td>Mean</td>
<td>28.49</td>
</tr>
<tr>
<td></td>
<td>SD</td>
<td>11.521</td>
</tr>
<tr>
<td></td>
<td>Adjusted mean</td>
<td>29.098</td>
</tr>
<tr>
<td></td>
<td>$F$</td>
<td>5.435*</td>
</tr>
<tr>
<td>Final exam</td>
<td>Experimental group</td>
<td>N=47</td>
</tr>
<tr>
<td></td>
<td>Mean</td>
<td>33.60</td>
</tr>
<tr>
<td></td>
<td>SD</td>
<td>11.721</td>
</tr>
<tr>
<td></td>
<td>Adjusted mean</td>
<td>34.156</td>
</tr>
<tr>
<td></td>
<td>$F$</td>
<td>11.106**</td>
</tr>
</tbody>
</table>

Note. **$p < .01$. *$p < .05$.

Table 3. Results of ANCOVA with repeated measures of the two groups’ cognitive test scores in the midterm exam, second quiz and final exam

<table>
<thead>
<tr>
<th>Variables</th>
<th>N</th>
<th>Mean</th>
<th>SD</th>
<th>Adjusted mean</th>
<th>$F$</th>
<th>Post hoc (Bonferroni)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1)Midterm exam</td>
<td>94</td>
<td>29.21</td>
<td>10.85</td>
<td>29.33</td>
<td>12.47**</td>
<td>(1)&gt;(2)</td>
</tr>
<tr>
<td>(2)Second quiz</td>
<td>94</td>
<td>26.99</td>
<td>11.44</td>
<td>27.02</td>
<td></td>
<td>(3)&gt; (2)</td>
</tr>
<tr>
<td>(3)Final exam</td>
<td>94</td>
<td>30.93</td>
<td>11.77</td>
<td>30.99</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note. **$p < .01$.

In addition, ANCOVA with repeated measures was employed to compare the differences in the two groups’ cognitive test scores between the midterm exam, second quiz and final exam. The Mauchly Spherical test showed that $X^2 = 1.70$ ($df = 2; p = 0.428 > 0.05$), implying that ANOVA with repeated measures could be employed. As shown in Table 3, the adjusted means of the three tests were 29.33, 27.02 and 30.99, respectively. A Bonferroni test revealed that the test scores of the midterm exam and final exam were significantly higher than those of the second exam.
quiz with $F = 12.47$ and $p < .01$. That is, PUMDCTS benefited the students more in the midterm and final exams than in the second quiz.

To further investigate the effect factors, we accessed the students’ test records as shown in Figure 8. We found that during the second quiz (the number of practicing questions for the experimental group is 36,431 and that for the control group is 29,576), the number of times the students used PUMDCTS was significantly reduced compared with before the midterm and final exams. One possible reason is that, when facing different exams, the students’ attitudes towards preparing for the exams and their learning desires will be different. For the midterm and final exams, the students may have taken more time and put more effort into practicing on the system than for the second quiz, so the difference between the two groups in the midterm and final exams was more significant, while it was not so significant in the second quiz.

The results of the first stage - the learning effectiveness of the technical tests

In addition to analyzing the learning effectiveness of the cognitive tests, this study also explored the impact of the use of PUMDCTS on the students’ web design abilities. The students’ web design abilities were evaluated by the scores of the technical tests. The results are shown in Figure 9. For the pretest, the average scores of the experimental and control groups were 41.17 points and 41.28 points, respectively. They were very close and had no significant difference. This indicated that the prior knowledge of the two groups was about the same. For the midterm exam, the average scores of the experimental and control groups were 36.60 points and 36.70 points, respectively. There was also no significant difference between the two groups. After the second quiz, the average scores of the experimental and control groups were 39.15 points and 37.55 points, respectively. Although they did not reach significant difference, it can be seen that the average gap between the two groups in this exam was 1.6 points. Finally, for the final exam, the average scores of the experimental and control groups were 33.11 points and 30.32 points, respectively. Although they still did not reach significant difference, the gap between the two groups increased by an average of 2.79 points.

<table>
<thead>
<tr>
<th></th>
<th>Pretest score</th>
<th>Midterm exam score</th>
<th>The second quiz score</th>
<th>Final exam score</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Experimental group</strong></td>
<td>41.17</td>
<td>36.6</td>
<td>39.15</td>
<td>33.11</td>
</tr>
<tr>
<td><strong>Control group</strong></td>
<td>41.28</td>
<td>36.7</td>
<td>37.55</td>
<td>30.32</td>
</tr>
</tbody>
</table>

Figure 9. The exam score graph of the technical tests during one semester

To sum up, although the two groups did not reach statistically significant difference for the technical tests, the use of PUMDCTS may have played a positive role in promoting the students’ web design capabilities, and a positive transfer of learning from the cognitive tests to the technical tests may have taken place. As indicated by Huang, Huang, Wang, and Hwang (2009), the transfer of learning from one subject to another could be stimulated in electronically mediated courses. Therefore, in our future study, it is expected that more conclusive results can be obtained by extending the experimental time to one year or more.

The results of the second stage - interviews regarding the system’s usefulness

This section discusses whether PUMDCTS was helpful for acquiring the knowledge of the certification exam and the web design course. In addition, whether the Bloom diagnostic light table was helpful to the learners is also explored.
After the interviews, the respondents generally felt that the use of PUMDCTS helped them learn the content of the certification exam and the web design course. In terms of acquiring knowledge, the respondents expressed comments the same as or similar to the following: “Using PUMDCTS really helped the learning for the certification exam” (STA01, STA02, STA06, STA15) and “Using PUMDCTS can contribute to learning web design and other related knowledge” (STA02, STA03, STA11, STA13, STA14).

Regarding the personalized strengthening practice mechanism and Bloom diagnostic light table, the respondents expressed the same/similar comments as follows: “The lights can give me a better understanding of my weaknesses in learning HTML, can give me a deeper impression, and can enhance my memory” (STA05, STA10, STA13, STA15) and “I can find out the direction of the problems and it is easier to understand my own learning status (STA01, STA08, STA09, STA13, STA14).”

However, some respondents gave negative comments, including the same as or similar to: “The question repetition rate of the personalized strengthening practice mechanism is too high” (STA02, STA03, STA08, STA14, STA15). This indicates that the strengthening practice mechanism needs to be improved.

The results of the second stage - interviews regarding the system’s ease of use

According to their responses in the interviews, the respondents generally believed that the multi-device certification tutoring system made it more convenient for them to learn, and they were willing to continue using it. They gave positive responses regarding the multi-device design and expressed comments such as: “I can easily use the system anytime and anywhere (STA03, STA15, STB01, STB08).”

However, the respondents also expressed some negative comments which were mostly related to the layout design. Two representative comments are: “The page layouts of navigation for the questions and score inquiries were not so good” (STA09, STA11, STB08) and “You can’t go back to the previous question (STA11, STA12, STB04, STB08).”

The results of the second stage - interviews regarding learning motivation

In this study, to get students to learn in a healthy competitive way so as to enhance their learning motivation, we designed experience rankings. In this interview, some learners expressed that through the competitions they had a greater willingness to use the system. They expressed comments such as: “The system allows me to interact with classmates and have a good competition, which makes me have a strong wish to outperform my classmates (STA06, STA10, STA12).”

Discussions, contributions and suggestions

From Figure 8, it can be seen that the number of practice questions for the experimental group is totally 166,117 compared with 110,005 for the control group. During the experiment, the experimental group practiced with PUMDCTS more frequently than the control group practiced with the traditional tutoring system. We infer that this is one reason why the experimental group showed better learning achievements than the control group in the cognitive tests.

To summarize the above, our contributions are as follows. In the past, very little research has proposed tutoring systems which combine these functions. In addition, the strengthening practice mechanism implemented by probability according to the light being red, yellow, green, or white is firstly proposed. The system evaluation results showed that there was a positive influence of PUMDCTS on the cognitive tests, while its influences on the technical tests was not significant.

The system implementation techniques and the experimental findings can be a reference to educators and/or educational system developers. Based on the findings of this study, it is suggested that teachers or researchers who intend to improve students’ learning performance in programming courses pay attention to the provision of personalized guidance to individual students based on their learning status and knowledge levels, as indicated by
Wang et al. (2007) and Cho et al. (2003). This can be done by considering the following procedure: (1) Classifying the exam questions based on Blooms’ six categories or other test-item categorizing schemes, such as the concept effect model suggested by Hwang, Panjaburee, Triampo and Shih (2013); (2) adopting a learning diagnostic mechanism based on the exam question classification scheme; (3) analyzing students’ learning status and needs based on the learning diagnostic mechanism; and (4) providing personalized guidance to individual students based on the diagnostic results.

Conclusions and future work

In this study, by combining Bloom’s Taxonomy of Educational Objectives, we developed a multi-device personalized certification tutoring system. We also analyzed the students’ scores on the cognitive tests and technical tests in one semester. In addition, interviews were conducted after the experiment. According to the analysis of the students’ scores and the interview contents, we summarize the findings as follows:

- By incorporating Bloom’s theory, the proposed system can enhance the students’ effectiveness in acquiring certificates and related knowledge.
- The personalized strengthening practice mechanism and Bloom diagnostic light table can help students better understand their learning status.
- The multi-device design approach can help students more conveniently use the system.

From the analysis of the experimental results, in the future, a more long-term observation can be made to explore whether the use of PUMDCTS has a significant impact on web design capabilities. For students with different learning styles and cognitive styles, whether the use of PUMDCTS results in different impacts can also be explored. We hope that the research can be more comprehensive through the collection of a wider range of data.

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References


Twitter as a Learning Community in Higher Education

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ABSTRACT

Considering the potential and popularity of social media it is important to inquire into its use in learning. In this study the implementation of the activity carried out in Twitter with higher education students was analysed. The research was conducted following a mixed methodology, based on virtual ethnography complemented by quantitative analysis of the tweets produced. A sample of 3,026 tweets was taken for such purpose. By way of conclusion, it is worth noting that student participation in the education process via Twitter progressively increases as their technical knowledge of this tool improves and they feel more motivated. Interaction and learning within a community is underpinned by gratifying experiences. Thus, the use of Twitter in the learning process of university students is feasible and perceived as a motivating experience by them. However, teachers play an essential role as dynamisers in the formal incorporation of Twitter in the teaching process, as well as in enhancing interaction between the participants.

Keywords

Twitter, Social networks, Networked learning, Higher education

Introduction

Didactic methods incorporating the new technologies are evolving slowly, which is why teachers should also update their skills to include the use of Information and Communication Technologies (ICT). Still, these resources are starting to contribute to the promotion of new forms of learning, forming part of a new emerging paradigm involving the construction and production of knowledge in cyberspace. Access to such knowledge makes vast quantities of information available to people, instantaneously or with a certain time delay, as well as facilitating contact with and knowledge of countless resources and communication platforms in any place at any time (Johnson, Smith, Willis, Levine, & Haywood, 2011; Kop, 2012). The Internet is a valuable resource in higher education, especially as a means of bridging long distances, thereby promoting the feedback process, a key component of learning. Moreover, it promotes the motivation and regulation of students in the training process.

Certain authors go even further (Fried, 2008; Hembrooke & Gay, 2003), indicating that ICTs have a negative impact on learning, as they disperse attention and promote the diversification of the type of tasks carried out on an autonomous basis. Although other researchers as Hsu and Ching (2012) indicated that the proliferation of Web 2.0 applications – especially the social media – among people and the ever greater use of mobile devices also contributes to broaden the possibilities of ubiquitous, collaborative learning. Still, the Internet as a source of learning continues to expand and gain ground, as it generates and facilitates communication and the acquisition of a great number and diversity of resources, and provides different ways to apply fundamental principles of learning in higher education (Gernsbacher, 2015). It is also worth noting that it gives rise to knowledge, though most of its content is not directly associated with regulated learning and the physical space of classrooms. On the Internet we can all be consumers, creators and disseminators at the same time. This is one of the premises of the EMIREC model (Cloutier, 1975): any emitter is a receiver and any receiver is also an emitter.

Kaplan and Haenlein (2010) define social media as the applications that are supported on the Internet and are based on the ideological and technological foundations of Web 2.0 and allow creating and interacting with contents generated by users by open and free means. In this sense, Khan (2013) outlined that they provide opportunities to users to develop relationships, communication, and collaboration (sharing contents). These social media integrate a large variety of emergent tools and technologies as wikis, blogs, and microblogging, content communities (YouTube, Pinterest, Slideshare), social nets (Twitter, Facebook, etc.), social tagging and folksonomies (Delicious, Addthis, Diigo), online games, collaborative platforms, and other web 2.0 platforms where users create, exchange, comment,
and value their own contents. Today no one questions the great educational potential of Web 2.0 tools, but their integration into learning contexts still has to take off, and one cannot as yet speak of widespread use.

Díaz-Gandasegui (2011) holds that social media are one of the main sources of leisure among the younger generations. This helps them to acquire the technical skills required for the use of the new technologies, although it does not ensure a widespread familiarisation or acquisition of skills within this group. It is also worth noting that, owing to the way in which they invade people’s lives, social media can be seen either as a potential threat, or alternatively as a great opportunity that can be extended to different facets (Stoughton, Thompson, & Meade, 2015). However, the use of social media as a didactic tool is still at an incipient stage, despite the accessibility made possible by their application, as they are easy to use and available as an open resource on the Internet.

The social media constitute, together with the Internet, a phenomenon that has changed the way in which people and groups or communities communicate and socialise, the way in which interaction, collaboration and content creation take place. At present their repercussion is most notable. We can find a variety of examples of their application to everyday situations and in particular to extreme or exceptional circumstances (involving catastrophic weather events, tragedies caused by transport accidents, political issues, etc.), which have demonstrated the effectiveness of the use of the social media as a means of communication and mobilisation of thousands of individuals. In this respect, Dunn (2011) refers to the use of Twitter for coordination purposes in the mobilisation and organisation of massive demonstrations. From the foregoing it may be inferred that social media render a substantial service to citizens, providing a revolutionary and different way of communicating.

The idea that learning is a socio-cultural process requiring internal dialogue and motivated interaction with others (Johnson, 2009; Vygotsky, 1982) is fairly well established. This notion endorses Twitter as a useful tool in the construction of knowledge, particularly when the training process is carried out in a social manner from a connectivist point of view (Siemens, 2005). Dunlap and Lowenthal (2009) maintain that, for online learning to be really effective, it must facilitate the communicative and social process.

Undoubtedly, through the Twitter Social Network, whose use is freely promoted by users themselves, communication and interconnection are generated, and content is created and disseminated at tremendous speed and on a great scale, as one would expect of a mass medium. A study demonstrated that Twitter can be used to increase the learning process: the number of tweets is related to student’s engagement in university, the learning tweeting is not influenced by interpersonal relationships between students and their tutor; and Twitter usage do not impact class attendance (Evans, 2014). By the way, Twitter was employed to improve writing, to develop reflection, and to expanding the class community (Kassens, 2014).

It is worth noting the application of the social media, specifically Twitter, to various institutional purposes such as, in the case of universities, the launching, promotion or diffusion of marketing initiatives; student recruitment; and communication with alumni besides its usefulness as a means of academic support (Palmer, 2013). So far, as we have already indicated, the application of social media to the academic context is considered incipient and there are few studies highlighting its interest for educational praxis. In fact, certain authors (Tess, 2013) contend that there are still grounds for considerable reticence, indicating that there a few solid studies arguing in favour of the usefulness and efficacy of the social media in the university context; at the same time, other researchers praise their benefits based on experiences with different groups in higher education and state that when students are conditioned to use Twitter in the learning process and teachers become systematically involved in the implementation of activities, their participation and performance improves satisfactorily (Junco, Elavsky, & Heiberger, 2013). Therefore, the degree of interaction between teachers and students, together with a suitable design and regular performance of academic work in a network environment are key components for the attainment of successful results with the Twitter Social Network.

Added evidence in this respect is provided by the review carried out by other authors (Greenhow & Gleason, 2012; Veletsianos, 2012) based on the content of education and technology journals and some multidisciplinary publications, revealing that the research published to date on the use of Twitter in training contexts is quite scarce. Hence, it should be taken into account that there are still no solid methodological models for the didactic use of the Web 2.0 tools in general and Twitter in particular. Therefore, it is important to share the alternatives arising from research and any incipient experience, making use of good practices based on, at least, specific initiatives or case studies. Yakin and Tinmaz (2013) consider that such works can provide interesting results and conclusions on the
effective use of Twitter in education. Moreover, in order to avoid obsolescence, universities must incorporate innovative teaching-learning dynamics including the social media. It should also be taken into account that the values and mechanisms deriving from the digital culture (transparency, collaboration, accessibility, etc.) are held in ever greater esteem.

The main aim of this work is to promote interaction through practice and to broaden through research the understanding of the manifestations of a networked learning community, in this case in the socio-educational field, within the Twitter virtual environment. Based on an experience carried out with students using this network as a learning medium in a master’s programme at Spain’s “Universidad Nacional de Educación a Distancia” (UNED), the teachers and researchers were able to investigate its application in the educational process. Several foci of analysis were applied to Twitter in order to reveal the background of the dynamics originated within the learning context, establishing the following research questions:

- How is the performance of the academic activity realised with Twitter?
- In what ways does the student’s production in Twitter change as the training process progresses?
- What is the students’ response time in the Twitter-specific activities?
- How does interaction through retweets evolve?
- What are the main problems arising with the use of Twitter?

**Context, didactic design and implementation in Twitter**

As indicated earlier, the study focused on a master’s programme at a Spanish university, entitled “Learning Communities in Social Networks,” and the teacher-directed period was concentrated into six months. Since UNED is a distance learning university, communication via the Internet is crucial. Moreover, the content of this course is well suited to its being carried out via a Social Network. The main Twitter features are: the limited message length to 140 characters (tweet); the public character of the communication; the message impact is related to the readers’ interest (followers); and its possible use as synchronous or as asynchronous means (Cohen & Duchan, 2012). These features make easier the learning of the tool, provide an easy access, and facilitate a free context for open communication. Thus, Twitter was selected, as its features were considered the most suitable to generate a learning community. However, the students’ learning process was reinforced through other resources (weekly seminars via web conferences and chats, with theoretical and practical content related to the course); guidance provided by the teachers; clarification of queries, etc.

The activities scheduled featured innovative didactic components, which were being used for the first time. Their development was mainly aimed at creating a learning community in cyberspace with the students. Taking into account the constraints of the time schedule established by the University for the teaching of the course, with a short time span, it was decided to implement 5 waves of activities on Twitter, from Monday to Wednesday, at a rate of 7 per day (making up a total of 105 activities). Additionally, the course teachers conducted a web conference every Thursday to address any academic issues raised by the students. An interactive methodology mainly based on the Twitter Social Network was developed to enable the various practical activities of the course to be carried out.

The instructions given by the teachers in the web conferences for working in Twitter, regarding the identification and presentation of the activities, focused on including the hashtags for the course, for the discipline, and the activity number, before the title, and the activity description. Thus, students had to include at least three hashtags in their replies. The following example is given by way of an illustration: “#MasterNetworksUned #NLC #17 Threats | Indicates threats (obstacles external to the group) to the empowerment of a NLC of elderly people.”

As required by the specific features of the Twitter Social Network, the activities were restricted to a maximum of 140 characters (including clean text and various web links) and to the possibilities offered by this tool via retweeting, user mentions, hashtags, favourites, direct and/or private messages, lists and possible searches.

The methodology is based on learning by doing and collaborative learning (Kalantzis & Cope, 2012; Ricoy, Feliz, & Sevillano, 2010). Students have to experience the learning community by participating in one doing significant activities implemented via Twitter that can be grouped into 12 categories: debate on the social media; adding new information via resources provided as a file attachment; completing information on an individual basis; using content analysis techniques such as SWOT Analysis (Strengths, Weaknesses, Opportunities, and Threats); creative linking of
ideas through the use of dedications; clever games with literary licences; conducting information searches on the web following specific instructions; requests for analytic changes in the titles of activities provided; collaborative creation of designs based on a specific proposal; questions on opinions about or experience with social media; assessment and review of contributions on tweets displayed; and word and letter games on curriculum design.

Research methodology

The present study was conducted following a mixed methodology, using a case study. Initially, within the framework of qualitative methodology, virtual ethnography techniques were used to address problems arising from the implementation of the experience based on Twitter. The use of virtual ethnography allows determination of the way in which people act and interact in a digital environment, giving meaning to social relations and the training process it transcends in cyberspace.

The research methodology used (qualitative-quantitative) allowed several different foci of analysis to extract additional and complementary results (Creswell, 2012): external (involving the identification of the problems and solutions offered to the different situations arising during the implementation of the activity with Twitter), internal (involving a description of the reactions, group atmosphere, etc.) and temporal (placing the previous two in their respective phases: initial, central and final) reflecting the changes that take place. In this manner it was possible to determine and understand the reality analysed from a threefold perspective: subjective, objective, and temporal (Clandinin & Connelly, 1995).

Participants

In accordance with the foregoing, the present study was carried out with a group of students of “Universidad Nacional de Educación a Distancia” (Madrid, Spain) enrolled in the course “Networked Learning Communities” forming part of a master’s programme offered by the university entitled: “Social Networks and Digital Learning.” A total of 39 people participated: 19 students in the course; the 2 course teachers, 2 other teachers from the master’s programme; and 16 external participants (those included in the last two groups joined freely). As regards gender, overall the participation was very balanced, with 20 male (51.28%) and 19 female participants (48.72%).

Of the 19 students registered in the course: 11 were teachers, 3 were journalists and 5 had other occupations (associated with IT, social work, scenography, economics and law). Their ages ranged between 21 and 50: 6 students between 21 and 30; 7 between 31 and 40; and 6 between 41 and 50.

Procedure

For the present study, the teachers combined their teaching and research activities. For such purpose, during the implementation of the experience they shared a digital diary running on “Google Drive” setting out their main achievements, incidents, problems or thoughts through the participant observation of Twitter activity and the weekly webconferences, and creating alternatives or solutions to address existing needs. The instruments for this ethnographic phase were:

- Hootsuite, to observe and store the Twitter activity.
- Learning platform, recording weekly webconferences.
- Group students’ final reports, with questions and reflecting activities about their experience.

In addition, through the cooperation among the teachers, supported by Internet tools (essentially HootSuite that allows keeping streams generated by activities hashtags), it was possible to monitor the students during the implementation, retrieve the tweets with the authors’ and timing data identifying them with the course hashtags (keeping them in txt format, separating fields by tabulators and pasting them in a spreadsheet file), and analyse the information obtained, initially, through the training activity carried out in Twitter, an incipient analysis was carried out fairly swiftly in order to provide, when required, diligent solutions. Finally, the students’ final report provided also relevant comments about their experience throughout the course. This was subsequently followed by a more in-depth analysis using “Analysis of Qualitative Data” (AQUAD) software. For this analysis, several files were
uploaded in the software: diary about observations of Twitter activities, each webconference recording, and each group report. The analysis methodology was based on content analysis procedures, using sentences as analysis units and coding categories related to the research questions (Yin, 2009; Zhang & Wildemuth, 2009). The two research questions focussed in this phase were: (1) How is the performance of the academic activity realised with Twitter? (2) What are the main problems arising with the use of Twitter?

According to Hine (2003), understanding how the interactions and the learning process take place requires integration between the members participating in a Social Network, such as Twitter, forming part of the community subject to analysis as outsiders and natives. This immersion into virtual communities with a training purpose allows, from a twofold perspective, as teachers and researchers, valuable data to be obtained for their in-depth study. Tierney (2012), among others, maintains that social media are an invaluable source of information subject to analysis.

Upon completion of the virtual training course, and hence of the tutored implementation of the learning process, the tweets were collected using Hootsuite to identify the course hashtags. These posts were pasted in a spreadsheet with these fields: tweet text, author’s user, publication time, and indication of number of retweets. The software allows searches, counting, and calculating using operators as “find,” “count,” “average,” etc. Each piece of data was located in a specific column to facilitate statistical options of analysis. Excel 2007 software was used to undertake different statistical analyses (frequency, percentage, mean and trend) on the nuclei under study.

Results

This section is divided into two subsections describing the main results of the qualitative and the quantitative analysis, respectively.

Qualitative results

The qualitative results presented here were obtained by monitoring the entire training process carried out via Twitter, together with a subsequent in-depth evaluation by means of content analysis. This made it possible to detect different problems, solutions, and identify the main achievements of the activity implemented via Twitter. Figure 1 below shows the results of the central foci of the analysis, with regard to the three phases identified. In the subsequent explanation, the evidence source and examples are indicated in brackets.

![Figure 1. Overview of the work in Twitter in the respective phases](image-url)
Initial phase

- Previous experience with Twitter: All the students stated they had some previous knowledge of Twitter use, although they showed scarce skills (Source: first and second webconference; students’ questions about procedures; Twitter activity, e.g., all the student’s accounts were created some time ago).
- Lack of ingenuity: This had the effect of limiting the students’ initial response in the activities proposed, and as a result the preliminary work was rather poor, showing a considerable lack of creativity. In the students’ first interventions in Twitter, we find simple replies, lacking in depth (Source: Twitter activity and final report, e.g., initially, students answered briefly to questions as in a questionnaire with single words; in addition, they recognised in their report that they did not take advantage of Twitter potentialities).
- Lack of interaction: The absence of interaction is reflected on the publication carried out by the participants with the tweets, characterised by very individual contributions, without involving themselves in other people’s contributions or linking them to those of other group members. This was seen as a cause for concern by the teachers (Source: diary, e.g., the answers did not refer to over answers, they did not discuss, they did not use retweets and did not mark favourites), since there was no two-way communication other than replies directly addressed to the teacher. This was compounded by the virtual absence of retweets, as the evaluation of other interventions plays an important role in establishing a connection between the members of a learning community and strengthening its links. The teachers pointed out this weakness to the students and reinforced their motivation through various practical activities in an effort to reorient the direction of the messages and their production by the students.
- Technical difficulties: the main difficulties were centred on the use of hashtags and the abuse of the answer in their participation (Source: Twitter activity; e.g., some answers were not in the hashtag streams; the mention number of professor’s accounts was quite high). Influenced by their mail experience, they use to use the answer option. However, in Twitter, that means a mention, introducing the user as a way to focus him in the communication. By the way, the hashtags are lost. To participate in this kind of community, you have to copy and past the hashtags and indicated previously and to use the mention, that means the answer, only when you want to focus a specific user or tweet. This points were clarified in the 2nd and 3rd webconference.

Central phase

- Use of a greater number of resources: As the activity progressed and the students improved their skills, the complexity of the practical activities proposed was gradually increased and the students were encouraged to use a greater number and variety of resources as documents, texts, blogs, posts in social media, presentations, games, videos, audios, images, photos, sites, etc. (Source: Twitter activity; e.g., occurrence of links to external sites).
- Improvement of interaction: the resource increase and the improvement of the tool management were found to have a positive impact on the level of interaction within the group, as evidenced by a better atmosphere and greater maturity in the community, leading to an improvement in the students’ academic level and the quality of the communication produced (Source: Twitter activity and webconferences; e.g., students’ comments in webconferences; lower number of professor’s mentions).
- Increased engagement: Progressively, with the teachers’ encouragement, the participants expressed their expectations of achievement and feelings of confidence and enthusiasm towards community learning, increasing their interaction (Source: webconferences and final report; e.g., students’ comments and valuations).
- Increased interest in learning: During this central period of the implementation of the academic activity, as the students’ interest increased, the teachers introduced activities with game ingredients, involving both the type of activities proposed in Twitter, and the feedback in the weekly webconferences (Source: Twitter activity and webconferences; e.g., number of tweets and quality in answers).

Final phase

- Discovering new ways for collaborative learning: In the final period of implementation the dynamics applied strengthened the development of a new form of community learning, of expressing oneself, of interacting and collaborating. In addition, the students found it progressively easier to adapt and synthesise their messages
(Source: Twitter activity; they interact with other students and combine general asseverations with arguments and mentions focussing other users’ statements; they link to blogs, posts, and sites).

- Integration of a large number of learning resources: Their syntheze capability was also reflected through the use of multiple resources available on the Internet (videos, images, presentations, comics, press news, didactic materials, etc.) instead words (Source: Twitter activity; e.g., they link to Pinterest, Instagram or YouTube contents that bases their arguments).
- Awareness of the evolution of competence acquisition: In this final stage the participants stated that, among other aspects, the use of the Twitter tool in the training process allowed them to improve their reflective and critical judgement competencies (e.g., increasing the number of arguments and references to other students’ statements), their information searching and selection skills (e.g., providing references and links in their arguments), their collaboration with other members and their interaction with the group (e.g., increasing references and interactions as retweets and favourites) (Source: Twitter activity and final report).
- Comprehension of the learning sense based on the interaction: They further added that the Twitter Social Network provided a twofold benefit – in the training process and in the sphere of communication (Source: final report; e.g., the valuation of their experience).

**Quantitative results**

The main quantitative results obtained from the production generated by the students during the training process via the Twitter Social Network are given below. These refer to: the number of tweets, their degree of concentration depending on the day of the week, the response delay time, and the number of retweets occurring per week.

![Number of tweets generated per week](image)

The student’s production in Twitter regarding the training activity subject to analysis took place during the months of June and July 2013. Over a six week period the level of participation in the Twitter Social Network shows an initial upward curve with a certain progressivity (Figure 2), with a steep rise during the 3rd (539 tweets), 4th (529 tweets) and 5th weeks (529 tweets) of the course, and a fall to a level similar to the first two weeks during the final week.

While the trend observed is reasonably in accordance with what might be expected, the irregular participation pattern over the different days of the week is quite striking, with a concentration around the days in which the teacher proposed the activities: Monday (28.75%), Tuesday (29.11%), and peaking on Wednesdays (33.31%). This had the effect of raising the overall participation figures, with a value of $M = 432.28$. Likewise, those same days show a considerable level of activity in the tasks carried out by the students (Figure 3). Consequently, it can be deduced that although it was a distance education course, with students averaging over 30 years old who combined their studies with their jobs and other occupations (family, household or leisure), they did not devote their weekends to training.
activities in this topic in Twitter. Unfortunately the level of learning activity via Twitter was extremely low on Fridays and Sundays (0.99 % and 0.13 %, respectively) and non-existent on Saturdays, as shown by the trend curve.

Moreover, it was observed that, although Twitter does not require the participants to be present simultaneously, since it is an asynchronous medium, the response delay time for the activities was in most cases very short (Figure 4). The practical activities were carried out mostly on the same day (77.36%) in which the teachers launched the proposals via the Twitter Social Network or on the day after they were proposed (21.58%), with an insignificant level of activity on the third day (1.06%), as reflected by the trend curve (though resulting in a high value of \( M = 1008.67 \) in overall terms). This indicates the commitment among the students was mediated by the training process, bringing the performance of the practical activities to a stop in subsequent days, despite the time interval before the launching of a new wave of activities.

Figure 3. Number of tweets according to the day of the week

<table>
<thead>
<tr>
<th>Day</th>
<th>Sunday</th>
<th>Monday</th>
<th>Tuesday</th>
<th>Wednesday</th>
<th>Thursday</th>
<th>Friday</th>
<th>Saturday</th>
</tr>
</thead>
<tbody>
<tr>
<td>Occurrence</td>
<td>4</td>
<td>870</td>
<td>881</td>
<td>1008</td>
<td>233</td>
<td>30</td>
<td>0</td>
</tr>
<tr>
<td>Percentage</td>
<td>0.13</td>
<td>28.75</td>
<td>29.11</td>
<td>23.31</td>
<td>7.70</td>
<td>0.99</td>
<td>0.00</td>
</tr>
<tr>
<td>Mean</td>
<td>432.28</td>
<td>432.78</td>
<td>432.78</td>
<td>432.78</td>
<td>432.78</td>
<td>432.78</td>
<td>432.78</td>
</tr>
</tbody>
</table>

Figure 4. Response delay time

<table>
<thead>
<tr>
<th>Time after Launch</th>
<th>Same day</th>
<th>Next day</th>
<th>Two days after</th>
</tr>
</thead>
<tbody>
<tr>
<td>Occurrence</td>
<td>2341</td>
<td>653</td>
<td>32</td>
</tr>
<tr>
<td>Percentage</td>
<td>77.36</td>
<td>21.58</td>
<td>1.06</td>
</tr>
<tr>
<td>Mean</td>
<td>1008.67</td>
<td>1008.67</td>
<td>1008.67</td>
</tr>
</tbody>
</table>
It is worth highlighting that out of a total of 3,026 tweets produced, 977 were retweets (32.29%). In response to the dynamic deriving from the characteristics of the platform used, the retweet is used as a support mechanism for the contributions between the members of the group. As evidenced by the quantitative analysis, since the monitoring of the process showed that the students were not spontaneously using the retweet from the outset, the teachers used different strategies and means (webconferences, chats, etc.) to emphasise the need for retweets and invite the students to use them. The retweets and the favourites are the two ways that Twitter provides to express agreement and support to other participants. Then they are two ways to increase interaction and develop the community. The teachers moreover included specific activities aimed at stimulating retweet use asking directly for retweeting the best answers in previous activities. This led to an observed rise in retweets during the course, with certain progressivity ($M = 195.4$), as can be seen from the trend curve (Figure 5). It is worth noting the substantial rise in this type of activity in the week before last (40.12%), followed by a sudden drop in retweet responses in the final week (16.99%), which, however, amply exceeded the production of retweets in the first week.

**Discussion and conclusions**

Based on the study we have carried out, it can be said that the use of Twitter in the training of university students is of great interest, the students’ answers improve as they advance and, in the final phase, they become aware of the evolution of their competence acquisition. Then as they progressively gain familiarity with the use of the tool, their learning improves. Consequently, the academic activity undertaken through the means of this Social Network for the teaching of courses included in the higher education curriculum, presents no problems for its implementation. In another study (Wang, Wang, & Shi, 2013), it was noted with regard to this issue that Twitter is well accepted by students for the performance of academic activities.

Beyond a catalysing function, the present study reveals that the use of Twitter to carry out training with university students is a feasible proposition. Moreover, it promotes a pleasant and motivating learning climate. However, the initial phase of the academic implementation is the least rich and least conducive to students easily sharing and analysing they knowledge generated digitally by them. However, such aspects can be overcome through teacher guidance and with the aid of the possibilities afforded by the Web 2.0 tools, enabling students to obtain information extremely swiftly (Thelwall, 2008).
Moreover, this study shows that the restricted number of characters allowed by this tool contributes to sharpen the ingenuity of the participants, who turn to the plentiful and varied resources available on the Internet. This points to the interest of integrating materials into learning, both of a general and of a didactic nature, free of charge and freely available for educational purposes, without requiring special adaptations. The brief style of expression required by this tool allows them to save time in the performance of a specific task, though on the other hand the need to synthesise sometimes tends to extend the time required. It is worth highlighting that the use of Twitter helps students to improve their reflective, critical judgment and information selection skills. In another work, Wrighta (2010) stresses the interesting role played by the use of Twitter, with its restricted number of characters in contributing to perfecting the reflective thought of participants.

The participation of the higher education students in the training process via Twitter progressively increased as their own technical competence in the use of the tool improved and they were incentivised by carrying out varied, novel and innovative activities. This production evolution was already observed in several contexts (Fang, Zhang, Ye, & Li, 2014). The lower levels of production by the students in this platform were concentrated at the initial and final phases of the training process. In the former case this was essentially associated with lack of habit, while in the latter case, as might be expected, the level of commitment and pressure fall off. We find the same pattern, with substantial variations, in the level of activity over the days of the week, with greater involvement in the days following the presentation by the teachers of the practical activities on the web. Thus, the students’ response was found to be contingent on the teacher’s immediate proposal, rather than showing a greater measure of self-regulation, commitment and balanced distribution of the work, even though, as adults, one might expect of them to combine them with other kinds of tasks, responsibilities and interests. The activity reduction during the weekends is not surprising and is common to other virtual tools as it has been studied (Feliz, 2012).

The response delay time is according with other previous studies (Khatri et al., 2015) and reveals that, although Twitter is an asynchronous means, participants answer mainly in the same day when the activity was published. This feature of Twitter has also been reflected during the warning phase of a disaster event (Sutton et al., 2014).

The fact that the participants are not fully acquainted with the interaction mechanisms particular to the Twitter Social Network leads to a more individual use at the outset. Teachers must stress this weakness (since the students are receptive) clearly referring to it (in their considerations and guidance) and reinforcing such skills in the students (by means of various supporting activities). It must be emphasised that for a learning community, the retweet, among other mechanisms, is one of the most binding. It should be noted that higher education students show a good level of receptiveness, education and maturity, which contributes to improving the socio-relational climate in cyberspace.

Finally, the present study reveals that the initial individualistic behaviour patterns exhibited by higher education students with the use of Twitter in terms of communication, mainly arising from a lack of habit, show great resemblance with those usually occurring in a face-to-face class, with a prevalence of the vertical mode of interaction. Some other detected problems are related to the specific procedure to create the community identity using special hashtags and the abusive use of the answering mechanism of Twitter that produces mentions but avoids hashtags and the other content of the tweet. Therefore, the guidance provided by teachers plays a useful role in raising the level of interaction within the group, through tweets and retweets, and in improving the procedures to develop the learning community. In this regard Junco, Heiberger and Loken (2011) point out that when the teachers are more committed to the use of Twitter, the students will show stronger commitment and will attain higher levels of achievement in their academic and interaction results.

References


The Effects of Attention Cueing on Visualizers’ Multimedia Learning

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ABSTRACT

The present study examines how various types of attention cueing and cognitive preference affect learners’ comprehension of a cardiovascular system and cognitive load. EFL learners were randomly assigned to one of four conditions: non-signal, static-blood-signal, static-blood-static-arrow-signal, and animation-signal. The results indicated that attention cueing yielded similar performance but helped reduce the learners’ mental load. No interaction effects between cognitive style and the experimental conditions on the learners’ total score and cognitive load were observed. Both high- and low-visualizers benefited equally well from attention cueing. However, an interaction effect in one subtest was observed indicating that attention cueing can result in learning interference among high-visualizers. Contrary to the hypothesis, the presence of attention cueing did not optimize conceptual understanding.

Keywords

Animation, Dual coding, Cognitive preference, Cognitive load, Signaling principle

Introduction

Without proper guidance, learners’ attention might become distracted when learning an unfamiliar subject in a multimedia environment. The presence of visual cues is assumed to direct learners’ attention to the most essential elements, help organize that information into a coherent structure, and optimize conceptual understanding (Mayer, 2009). According to the signaling principle, attention cueing is predicted to reduce learners’ extraneous load (Mayer & Moreno, 2010) and promote learning.

In addition, dual coding theory (Paivio, 1986) assumes that the human cognitive system has two independent but interconnected verbal and non-verbal mental systems. Active mental representation activates relevant nodes in the network, and the spreading activation triggers a wide range of associated verbal and imagery representations in the network. Past experiences and individual differences determine the quantity and quality of activation (Clark & Paivio, 1991). Learners’ cognitive preference (Hegarty, Kriz, & Cate, 2003; Plass, Chun, Mayer, & Leutner, 1998) and prior knowledge (Imhof et al., 2013) are predicted to moderate learning efficiency. Visualizers have been found to benefit from multimedia (e.g., Chen, Hsieh, & Kinshuk, 2008; Plass et al., 1998) due to their strong visuospatial capabilities in constructing mental models.

This study expands upon previous research conducted on the effects of attention cueing in multimedia learning with the aim of addressing the questions of whether or not attention cueing can reduce learners’ cognitive load and the ways in which different types of cognitive styles and attention cueing affect learning efficiency.

Literature review

Cognitive load theory

The information processing that occurs in working memory involves: (1) selection of relevant words, (2) selection of relevant images, (3) organization of selected words, (4) organization of selected images, and (5) integration of visual and auditory information with prior knowledge (Mayer, 2009). During information processing, three types of cognitive load may affect learning efficiency: extraneous, intrinsic, and germane. Extraneous cognitive load is caused by poor instructional design (Moreno & Mayer, 2010) but may be minimized by providing attention cueing (Mayer, 2009). Due to limited working memory capacity, the presence of attention cueing is predicted to direct learners’ attention to the target, thus minimizing the visual search process, releasing more cognitive resources with which learners can engage in schema construction and activation, and facilitate the germane load (de Koning, Tabbers, Rikers, & Paas, 2009), which is beneficial for learning.
Signaling principle

In terms of cognitive processing, attention cueing is classified into selection, organization, and integration cues – corresponding with the cognitive abilities of selecting, organizing, and integrating information in the working memory. Selection cues guide learners’ attention to the most essential elements in the representations (Crooks, Cheon, Inan, Ari, & Flores, 2012; de Koning et al., 2008, 2009). Organization cues assist learners in organizing the elements of the representations to better facilitate text processing and improve retention (Crooks et al., 2012; de Koning et al., 2008, 2009), such as number signals showing steps in causal chains to build up internal connections among causal elements (Harp & Mayer, 1998). Integration cues aid the learners in integrating the elements between and within the representations into a coherent whole (de Koning et al., 2009). In terms of perceptual processing, unique colors or moving objects seem to be effective in capturing learners’ attention. Two features that influence perceptibility of visual representations include visual contrast (i.e., an element with distinctive features stands out from the background) and dynamic contrast (i.e., movement or temporal changes in an element demonstrate figure-ground differences) which seem to direct learners’ attention to the target and reduce their extraneous cognitive load (de Koning et al., 2009).

Relevant studies about attention cueing in multimedia learning

Crooks et al. (2012) examined the effects of cueing and modality on a self-paced computer-based diagram depicting places of articulation in human speech. The learners were presented with either written or spoken text with the presence or absence of arrow and color cueing. No significant effects of cueing on learning efficiency and mental loads were observed. Lin and Atkinson (2011) investigated the efficiency of visual cueing in either animation or static graphics on learning rock cycles. Learners in both the visual and non-visual cueing conditions performed equally well and experienced similar cognitive load.

In a study conducted by Tabbers, Martens, and van Merriënboer (2004), they found that providing cues enhanced learning efficiency but yielded similar cognitive loads under all conditions. Imhof et al. (2013) also explored the effects of arrow cueing on learning fish locomotion patterns. The learning conditions included: (a) multiple visualizations without arrows, (b) multiple visualizations with arrows, and (c) single visualization with arrows. The first and third conditions were beneficial in facilitating learning efficiency by comparing multiple pictures or making dynamic information explicit. The second condition appeared to cause interference and hinder learning. The ineffectiveness of cueing on animation might be due to interference caused by the simultaneous highlighting of multiple elements without specificity (Moreno, 2007).

Similarly, Kriz and Hegarty (2007) conducted a study probing the effects of arrow cueing on learning a flushing cistern. The learners who received arrow cues did not significantly outperform those who did not receive arrow cues in comprehension and troubleshooting tests. The authors suggest that presenting attention cueing may help learners focus their attention only on the most relevant elements, but without ensuring effective conceptual understanding and mental model constructions of the visual representations.

Additional activities (i.e., display speed, self- or instructional explanations) accompanied with cues may help learners engage in deep learning (de Koning et al., 2009). de Koning and his colleagues conducted a number of studies by decreasing the luminance of uncued subsystems to show their visual contrast with cued subsystems in an animated cardiovascular system. In one study concerning presentation speed (de Koning et al., 2011a), the learners exhibited similar performance results on retention and transfer tests regardless of cueing conditions and display speeds. It was also found that low-speed group experienced a higher cognitive load than did those in high-speed conditions. This was probably due to the fact that in the low-speed condition, learners had to integrate and keep the information active in their working memory for a longer period of time which generated a greater extraneous load as compared with the learners in the high-speed conditions. In addition, the other two studies addressing the self- or instructional explanations accompanied with attention cueing (de Koning et al., 2010b, 2011b) yielded mixed results. Self- or instructional explanations accompanied by visual cueing seemed to optimize the learners’ conceptual understanding of the causal relations of animated cardiovascular system, yielded better performance, and reduced cognitive load. However, in terms of efficiency, the effect of self- or instructional explanations was unclear. On the
other hand, in their other studies, they found positive effects of attention cueing on learning efficiency as demonstrated by learners’ performances on transfer and inference tasks (de Koning et al., 2008, 2010b, 2011b).

Kalyuga, Chandler, and Sweller (1999) compared the effects of conventional separate-diagram-and-text and color-coded-diagram-and-text situations on learning an electrical circuit. The conventional group was given an electrical circuit with a written text underneath, whereas the color-coded-diagram-and-text group was presented with the same diagram and text but with additional color cueing on the electrical elements in which unique coloring schemes appeared when the learners clicked on the text. Those in the color-cueing group showed better test performance and lower cognitive load than did those in the conventional group. When dealing with split-attention diagrams where the text and diagrams are presented simultaneously, the text should be marked with color-cueing that draws the learners’ attention.

In sum, studies investigating the supposed benefits of visual attention cueing on multimedia learning efficiency have yielded mixed results. Administering attention cueing may facilitate learning efficiency (e.g., Amadieu et al., 2011; Boucheix et al., 2011; de Koning et al., 2010b, 2011b; de Koning & Tabbers, 2013; Imhof et al., 2013; Kalyuga et al., 1999) and reduce learners’ extraneous cognitive load (e.g., Amadieu et al., 2011; Kalyuga et al., 1999); or it may facilitate learning efficiency without reducing cognitive load (de Koning et al., 2008, 2010b; Tabbers et al., 2004); or it might be ineffective (e.g., Crooks et al., 2012; de Koning et al., 2010a, 2011a; Kriz & Hegarty, 2007; Lin & Atkinson, 2011; Moreno, 2007) and even causes interference (e.g., Imhof et al., 2013; Moreno, 2007).

Cognitive preference: Visualizers vs. verbalizers

Learners’ cognitive styles have also been thought to affect learning efficiency. However, previous studies investigating this theoretical assumption also showed inconsistent results. Studies conducted by Chen et al. (2008), Leutner and Plass (1998), and Plass et al. (1998) have indicated that visual representations benefit visualizers more due to their strong visuospatial capabilities in constructing mental models. However, Hegarty et al. (2003), Imhof et al. (2013), Jones (2009), and Plass et al. (2003) have found that visual representations may not support cognitive preferences. On the other hand, Höfler (2010) has even suggested that multimedia can compensate for verbalizers’ low-visuospatial capabilities and thus benefit them more.

Hegarty et al. (2003) conducted three experiments investigating learners’ mental animation ability on learning the mechanism in a flushing cistern. They found that providing learners with verbal text may be sufficient to help them construct mental imagery, while animation may not be superior to static diagrams in enhancing learners’ retention and troubleshooting abilities. Specifically, the high visual learners outperformed the low visual learners in all conditions but did not display significant interaction effects with the experimental treatments.

Statement of the problem

The issue over whether providing attention cueing enhances learning efficiency (e.g., Boucheix et al., 2011; de Koning et al., 2008, 2010b, 2011b; de Koning & Tabbers, 2013; Kalyuga et al., 1999) or fails to optimize learning (e.g., Crooks et al., 2012; de Koning et al., 2010a, 2011a; Harp & Mayer, 1998; Lin & Atkinson, 2011) remains controversial. Besides, previous studies used diagrams/animation alone, but the presentation of visual imagery without verbal explanations may be insufficient for learners to understand abstract concepts. Verbal texts that accompany diagrams/animation may vividly illustrate abstract concepts and benefit learners (Kriz & Hegarty, 2007). Finally, the ability to construct mental imagery is related to one’s visuospatial capabilities (Hegarty et al., 2003); however, whether high visual learners benefit from visual representations with attention cueing is under question. To address the unresolved questions, the research questions in the present study are as follows:

- Do learners perform differently on dependent measures in different learning conditions?
- Do learners in different conditions experience different cognitive loads?
- Do cognitive preference and experimental treatment affect learners’ performance and cognitive load?
Methodology

Participants

The participants were comprised of 169 undergraduates (male = 31, female = 138) with an average age of 19 ($M = 19.30, SD = 0.91$) enrolled in a foreign language department at a science and technology university in southeastern China. None of them had the background of biology, nor were they familiar with the material in the present study.

Prior knowledge level

A prior knowledge questionnaire with four statements was first administered to assess participants’ background (de Koning et al., 2008, 2011b). The learners self-rated their understanding of blood circulation by marking on a nine-point scale measuring their responses to the statements such as “My understanding of a cardiovascular system is…” and “My interest in reading books and magazines about medical science is….” A one-way ANOVA revealed no significant differences among the four groups, $F(3,166) = 0.51, p > 0.05$.

Variables

The experimental treatment and cognitive style were manipulated as between-subjects variables. Retention, pictorial recall, matching, and identification tests, and cognitive load were measured as dependent variables (Figure 1).

![Figure 1. Experimental design](image)

Independent variables

Cognitive style measurement

The learners’ cognitive styles were identified using the index of learning styles questionnaire, developed by Felder and Soloman (1997). The questionnaire comprised 44 alternative-choice questions. Learners with a rating at or above index 5 on the visual scale were classified as high-visualizers. Those with a rating at index 1 on the visual scale were classified as low-visualizers. A one-way ANOVA revealed no significant differences among the four groups, $F(3,166) = 1.196, p > 0.05$. 
Experimental treatment

The cues provided included selection, organization, and integration cues. The selection cues (i.e., the presence of blood guided learners’ attention to the target) were used in three experimental conditions, and they were assumed to reduce the learners’ perceptual load (Crooks et al., 2012; de Koning et al., 2009). Organization cues (i.e., the presence of number heading in three picture slides indicating steps of a heartbeat cycle) (de Koning et al., 2009; Harp & Mayer, 1998) were used in all experimental conditions. Integration cues (i.e., the presence of blood and arrows which helped learners connect related elements between and within the visual representations and explicated causal and temporal relations) were used in experimental conditions two and three, and they were assumed to help reduce the learners’ perceptual and cognitive loads (Crooks et al., 2012; de Koning et al., 2009).

Dependent variables

Retention test

The retention test, comprised of thirteen multiple-choice questions, was designed to assess how well the learners understood the instrumentation. Item 8 dealt with the structure of the heart; items 3, 4, and 11 were related to heartbeats; items 2, 9, and 10 focused on the functions of valves; items 1, 5, and 6 focused on contractions; and items 7, 12, and 13 dealt with blood circulation.

Pictorial recall test

The pictorial recall test, comprised of ten static pictures, was aimed at examining the learners’ comprehension of the instrumentation. Each multiple-choice question was comprised of one picture with four answer choices. Items 2, 9, and 10 dealt with the contraction of ventricles; items 1, 4, 5, and 6 were concerned with how blood returns from the body and collects in the atria; items 3, 7, and 8 dealt with the contraction of the atria.

Matching test

One static diagram concerning long and short loops was used to examine whether the learners could apply what they learned and indicate where blood flows in the human body. There were twelve labels in general terms rather than technical terminology (de Koning et al., 2011b) that needed to be matched with corresponding parts in the diagram. Items 1-4 dealt with the structure of the heart; items 5-8 were related to body parts; and items 9-12 dealt with how and where blood exchanges oxygen in the human body.

Identification test

One static diagram regarding long and short loops was to examine whether the learners could apply what they learned and mark the correct steps in the circulatory system on the diagram. There were ten blanks that needed to be filled in to show the steps in the blood circulation process.

Cognitive load measurement

A subjective cognitive load measurement with a scale ranging from 1 to 9 (Kalyuga, Chandler, & Sweller, 1999; Paas, 1992) measured learners’ cognitive load. Item 1-3 dealt with intrinsic load; items 4-6 probed extraneous load; and items 7-10 dealt with performance load.

Instrumentation

The texts and pictures were adopted from Knowledge—Encyclopedia, published by Dorling Kindersley, Inc., (2013). The text (335 words) and pictures (concerning heartbeat cycles) were made into PowerPoint slides. The instructional
materials included: (1) blood circulation, (2) heartbeats, (3) structure of the heart, (4) function of valves, and (5) heartbeat cycle. A time counter was above each slide to control presentation time, and each slide was presented only once for 40 seconds. The overall presentation lasted for six minutes.

In the fifth section, the written text was accompanied by three pictures illustrating: (1) filling up the atria; (2) contraction of the atria; and (3) contraction of the ventricles. The remaining sections contained written text only without pictorial illustrations.

Except for the introduction slide, the instructional materials comprised an average of about 35 words on each slide. In the fifth section, three pictures depicted each of the three steps involved in how blood circulates in and out of the heart. All the control and experimental groups were shown these three pictures in section five of the instrumentation. For the non-signal group (NSG), the slides contained written text plus static pictures without blood and arrow cues (Figure 2a). In the static-blood-signal group (SBG), the slides contained written text plus static pictures along with static blood cues embedded in the illustrations (Figure 2b). In the static-blood-static-arrow-signal group (SBSAG), the slides contained written text and static pictures embedded with static blood and arrow cues indicating the path and direction of blood flows (Figure 2c). In the animation-signal group (ASG), the slides contained written text with static pictures, but with animated blood and arrow cues indicating the movement path and direction of blood flow (Figure 2d). In the ASG, the animated arrows and blood were triggered by clicking the mouse and appeared gradually on the static diagrams to indicate how blood flows in and out of the heart. When the animation feature was in a resting state, the number and position of animated arrows and blood in the diagrams were the same as those in the SBSAG, except that the animation in the ASG was played three times to help learners capture the transiency of the animation.

![Figure 2. Sample screenshots in the control and experimental conditions](image)

**Experimental procedures**

The experiment was conducted during the students’ regular class period in a language laboratory containing 60 student seats and a computerized teacher control system from which the teacher could control the computer system and monitor all the students. The researcher sat at the computer system to control the presentation, as well as turn on/off the computer monitors.

First, the researcher gave students instructions regarding: (1) how to answer prior knowledge questionnaire, (2) how to answer the cognitive style measurement, (3) how to participate in activities pertaining to a cardiovascular system, (4) how to answer the retention, pictorial recall, matching, and identification tests, (5) what they were not allowed to do during the tests, and (6) how to complete the cognitive load questionnaire.

Prior to conducting the experiment itself, the students first filled out the prior knowledge questionnaire. Secondly, they completed the index of learning style questionnaire. Thirdly, they received 11 preview questions (one stem with four alternatives) presented on each student’s computer monitor as advance organizers to activate their prior knowledge (Herron et al., 1998). The preview questions presented in mandarin Chinese provided no clues for answering the forthcoming comprehension tests (Herron, 1994). Fourthly, they received the instrumentation. Fifthly, they received the retention, pictorial recall, matching, and identification tests sequentially on each student’s computer
monitor at their seat. The students needed to respond by writing down their answer choices on an answer sheet. They were not permitted to return to previous questions (de Koning et al., 2011b) to reduce the possibility of making inferences from them. They were also not allowed to return to previously-presented instructional materials, talk to their peers, or use a dictionary while taking the tests. However, they were permitted to complete the tests at their own rate. Finally, they completed a self-rated cognitive load questionnaire. After completing the tests and questionnaires, they handed in their answer sheets and left the laboratory. The data from the control and experimental groups were collected in separate class periods.

Data collection instruments

A pilot study involving 51 English majors was conducted prior to the experiment. Point-biserial correlation was conducted to examine the reliability of each measurement.

Self-rated prior knowledge scale (Cronbach’s alpha = 0.831)

Following item analyses, all items were preserved.

Retention test (Cronbach’s alpha = 0.77)

The students had to choose the best answer among the four alternatives in each question (Figure 3a). Each correct answer was worth one point. Following item analyses, two items (i.e., items 6 & 8) were removed and eleven items were retained.

Pictorial recall test (Cronbach’s alpha = 0.791)

The students had to choose the best answer among the four alternatives to describe the picture (Figure 3b). Each correct answer was worth one point. Following item analyses, three items (i.e., items 1, 3, & 6) were removed and seven items were retained.

Matching test (Cronbach’s alpha = 0.788)

The students were required to match each label with a corresponding body part in the diagram (Figure 3c). Each correct mark was worth one point and each ambiguous mark received no point. All items were preserved.
Identification test (Cronbach’s alpha = 0.955)

The learners had to mark the steps from 1 to 10 on the diagram (Figure 3d). Each correct mark was worth one point and ambiguous marks (i.e., random steps, scribble, etc.) received no points. All items were preserved.

All four subtests

Cronbach’s alpha of all 40 test items was 0.869 indicating that the measurement was highly reliable (Wu & Tu, 2006).

Cognitive style measurement (Cronbach alpha = 0.89)

Only the visual and verbal scales in the index of learning styles questionnaire were considered. The strength of the style was indicated by an index ranging from 1 to 11 with 1 representing the lowest level and 11 representing the highest level.

Cognitive load measurement (Cronbach’s alpha = 0.864)

Bartlett’s test of sphericity was significant and Kaiser-Meyer-Olkin Measure of Sampling Adequacy (KMO) was 0.866. The eigenvalue was greater than 1. The total explained variance was 56.876%, implying that the construct validity of the rating scale was good.

Results

Research question one: Do learners perform differently on dependent measures in different learning conditions?

The results of the one-way ANOVA indicated no significant differences among the four groups on the retention test, \( F(3,166) = 0.552, p = 0.648 \); the pictorial recall test, \( F(3,166) = 2.095, p = 0.103 \); the matching test, \( F(3,166) = 1.512, p = 0.213 \); the identification test, \( F(3,166) = 0.135, p = 0.939 \); and the total score, \( F(3,166) = 0.859, p = 0.464 \). The learners in the experimental groups did not outperform their counterparts in the control group (Table 1).

<table>
<thead>
<tr>
<th>Test</th>
<th>Sum of squares</th>
<th>df</th>
<th>MS</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Retention</td>
<td>Between groups</td>
<td>8.108</td>
<td>3</td>
<td>2.703</td>
<td>.552</td>
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<tr>
<td></td>
<td>Within groups</td>
<td>813.239</td>
<td>166</td>
<td>4.899</td>
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</tr>
<tr>
<td>Pictorial recall</td>
<td>Between groups</td>
<td>26.400</td>
<td>3</td>
<td>8.800</td>
<td>2.095</td>
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<tr>
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<td>Within groups</td>
<td>697.253</td>
<td>166</td>
<td>4.200</td>
<td></td>
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<tr>
<td>Matching</td>
<td>Between groups</td>
<td>28.292</td>
<td>3</td>
<td>9.431</td>
<td>1.512</td>
</tr>
<tr>
<td></td>
<td>Within groups</td>
<td>1035.614</td>
<td>166</td>
<td>6.239</td>
<td></td>
</tr>
<tr>
<td>Identification</td>
<td>Between groups</td>
<td>7.128</td>
<td>3</td>
<td>2.376</td>
<td>.135</td>
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<tr>
<td></td>
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<td>2919.225</td>
<td>166</td>
<td>17.586</td>
<td></td>
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<tr>
<td>Total score</td>
<td>Between groups</td>
<td>143.774</td>
<td>3</td>
<td>47.925</td>
<td>.859</td>
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<tr>
<td></td>
<td>Within groups</td>
<td>9260.720</td>
<td>166</td>
<td>55.787</td>
<td></td>
</tr>
</tbody>
</table>

Research question two: Do learners in different conditions experience different cognitive loads?

A one-way ANOVA using Tukey HSD test was used to compare the differences among the four groups in terms of intrinsic, extraneous, performance and overall cognitive loads (Table 2). There was a significant difference regarding intrinsic load, \( F(3,166) = 2.501, p = 0.045 \). Those in the NSG (\( M = 19.93, SD = 3.62 \)) had higher intrinsic load than...
did those in the ASG ($M = 17.05, SD = 4.89), $p = 0.042$. There was no significant difference concerning extraneous load, $F(3,166) = 1.611, p = 0.189$. There was a significant difference in performance load, $F(3,166) = 4.185, p = 0.007$. Those in the NSG ($M = 28.05, SD = 4.93$) had significantly higher performance load than did those in the SBG ($M = 23.47, SD = 8.11), $p = 0.012$; SBSAG ($M = 23.91, SD = 7.24), p = 0.036$; and ASG ($M = 23.81, SD = 5.99), $p = 0.023$. There was also a significant difference in overall cognitive load, $F(3,166) = 2.90, p = 0.037$. Those in the NSG ($M = 71.75, SD = 10.46$) had significantly higher overall cognitive load than did those in the ASG ($M = 62.81, SD = 14.35), $p = 0.042$.

**Table 2. Results of one-way ANOVA on cognitive load**

<table>
<thead>
<tr>
<th>Load</th>
<th>Group</th>
<th>$M$</th>
<th>$SD$</th>
<th>Source of Sum of squares</th>
<th>$df$</th>
<th>$MS$</th>
<th>$F$</th>
<th>Sig.</th>
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</thead>
<tbody>
<tr>
<td>Intrinsic</td>
<td>NSG</td>
<td>19.93</td>
<td>3.62</td>
<td>Between groups</td>
<td>3</td>
<td>60.485</td>
<td>2.501</td>
<td>.045*</td>
</tr>
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<td></td>
<td>SBG</td>
<td>18.65</td>
<td>5.84</td>
<td>Within groups</td>
<td>166</td>
<td>24.183</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>SBSAG</td>
<td>17.84</td>
<td>4.92</td>
<td></td>
<td>166</td>
<td>24.183</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>ASG</td>
<td>17.05</td>
<td>4.89</td>
<td></td>
<td>166</td>
<td>24.183</td>
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<td></td>
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<tr>
<td>Extraneous</td>
<td>NSG</td>
<td>16.90</td>
<td>3.49</td>
<td>Between groups</td>
<td>3</td>
<td>27.580</td>
<td>1.189</td>
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<tr>
<td></td>
<td>SBG</td>
<td>14.91</td>
<td>4.70</td>
<td>Within groups</td>
<td>166</td>
<td>17.124</td>
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<tr>
<td></td>
<td>SBSAG</td>
<td>15.65</td>
<td>4.13</td>
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<td>15.91</td>
<td>4.07</td>
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<td>Performance</td>
<td>NSG</td>
<td>28.05</td>
<td>4.93</td>
<td>Between groups</td>
<td>3</td>
<td>188.157</td>
<td>4.185</td>
<td>.007**</td>
</tr>
<tr>
<td></td>
<td>SBG</td>
<td>23.47</td>
<td>8.11</td>
<td>Within groups</td>
<td>166</td>
<td>44.963</td>
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<tr>
<td></td>
<td>SBSAG</td>
<td>23.91</td>
<td>7.24</td>
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<td>166</td>
<td>44.963</td>
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<tr>
<td></td>
<td>ASG</td>
<td>23.81</td>
<td>5.99</td>
<td></td>
<td>166</td>
<td>44.963</td>
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<tr>
<td>Total loads</td>
<td>NSG</td>
<td>71.75</td>
<td>10.46</td>
<td>Between groups</td>
<td>3</td>
<td>675.757</td>
<td>2.900</td>
<td>.037*</td>
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<td></td>
<td>SBG</td>
<td>64.23</td>
<td>19.00</td>
<td>Within Groups</td>
<td>166</td>
<td>233.020</td>
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<tr>
<td></td>
<td>SBSAG</td>
<td>63.58</td>
<td>15.52</td>
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<tr>
<td></td>
<td>ASG</td>
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<td>233.020</td>
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</table>

*Note. *$p < .05$. **$p < .01$. ***$p < .001$.

Research question three: Do cognitive preference and experimental treatment affect learners’ performance and cognitive load?

A Pearson correlation revealed a statistically significant negative correlation between total score and cognitive load, $r = -0.202, p = 0.008$. As learners’ cognitive load decreased, their test performances increased, and vice versa.

A two-way ANOVA using Tukey as a post hoc test was conducted to examine the interactive effects between the experimental conditions and cognitive style on the four subtests and total score (Table 3). The ANOVA source of variation results indicated no interaction effects on the retention test, $F(3,161) = 1.174, p = 0.321$, partial $\eta^2 = 0.021$; on the pictorial recall test, $F(3,161) = 0.352, p = 0.788$, partial $\eta^2 = 0.007$; or on the matching test, $F(3,161) = 0.161, p = 0.923$, partial $\eta^2 = 0.003$. However, interaction effects were found on the identification test, $F(3,161) = 2.887, p = 0.037$, partial $\eta^2 = 0.051$. The one-way ANOVA and the follow-up contrasts comparing both high- and low-visualizers in the four conditions showed that the high-visualizers in the NSG ($M = 6.00, SD = 4.03$) significantly outperformed the high-visualizers in the ASG ($M = 3.25, SD = 3.88$), $t(80) = 2.207, p = 0.030$ (Table 4). However, the low-visualizers in the ASG ($M = 5.79, SD = 4.26$) had higher score than the low-visualizers in the NSG ($M = 3.81, SD = 4.18$), SBG ($M = 3.70, SD = 4.34$), and SBSAG ($M = 3.68, SD = 3.88$), but did not reach the significance level, $p > 0.05$. There were no interaction effects overall, $F(3,161) = 1.033, p = 0.380$, partial $\eta^2 = 0.019$.

**Table 3. Results of two-way ANOVA on tests**

<table>
<thead>
<tr>
<th>Source</th>
<th>Test</th>
<th>Type III sum of squares</th>
<th>$df$</th>
<th>$MS$</th>
<th>$F$</th>
<th>Sig.</th>
<th>$\eta^2_p$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group</td>
<td>Retention</td>
<td>9.308</td>
<td>3</td>
<td>3.103</td>
<td>.632</td>
<td>.595</td>
<td>.012</td>
</tr>
<tr>
<td></td>
<td>Pictorial</td>
<td>25.605</td>
<td>3</td>
<td>8.535</td>
<td>2.018</td>
<td>.114</td>
<td>.036</td>
</tr>
<tr>
<td></td>
<td>Matching</td>
<td>29.493</td>
<td>3</td>
<td>9.831</td>
<td>1.538</td>
<td>.207</td>
<td>.028</td>
</tr>
<tr>
<td></td>
<td>Identification</td>
<td>6.557</td>
<td>3</td>
<td>2.186</td>
<td>.129</td>
<td>.943</td>
<td>.002</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>139.956</td>
<td>3</td>
<td>46.652</td>
<td>.837</td>
<td>.475</td>
<td>.015</td>
</tr>
</tbody>
</table>
Table 4. Contrast test of the identification test results

<table>
<thead>
<tr>
<th>Group</th>
<th>Visual</th>
<th>M</th>
<th>SD</th>
<th>Contrast test of high-visualizers</th>
<th>Value of contrast</th>
<th>Std. error</th>
<th>t</th>
<th>df</th>
<th>Sig. (2-tailed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>NSG</td>
<td>High</td>
<td>6.00</td>
<td>4.03</td>
<td>NSG vs. SBG</td>
<td>.95</td>
<td>1.300</td>
<td>.731</td>
<td>80</td>
<td>.467</td>
</tr>
<tr>
<td></td>
<td>Low</td>
<td>3.81</td>
<td>4.18</td>
<td>SBSAG vs. ASG</td>
<td>2.04</td>
<td>1.213</td>
<td>1.679</td>
<td>80</td>
<td>.097</td>
</tr>
<tr>
<td>SBG</td>
<td>High</td>
<td>5.05</td>
<td>3.73</td>
<td>SBG vs. SBSAG</td>
<td>-.24</td>
<td>1.268</td>
<td>-.186</td>
<td>80</td>
<td>.853</td>
</tr>
<tr>
<td></td>
<td>Low</td>
<td>3.70</td>
<td>4.34</td>
<td>NSG vs. ASG</td>
<td>2.75</td>
<td>1.246</td>
<td>2.207</td>
<td>80</td>
<td>.030*</td>
</tr>
<tr>
<td>SBSAG</td>
<td>High</td>
<td>5.29</td>
<td>4.55</td>
<td>SBG vs. ASG</td>
<td>1.80</td>
<td>1.229</td>
<td>1.465</td>
<td>80</td>
<td>.147</td>
</tr>
<tr>
<td></td>
<td>Low</td>
<td>3.68</td>
<td>3.88</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ASG</td>
<td>High</td>
<td>3.25</td>
<td>3.88</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Low</td>
<td>5.79</td>
<td>4.26</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 5. Results of two-way ANOVA on cognitive load

<table>
<thead>
<tr>
<th>Source</th>
<th>Load</th>
<th>Type III sum of squares</th>
<th>df</th>
<th>MS</th>
<th>F</th>
<th>Sig.</th>
<th>η²p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group</td>
<td>Intrinsic</td>
<td>194.926</td>
<td>3</td>
<td>64.975</td>
<td>2.686</td>
<td>.048*</td>
<td>.488</td>
</tr>
<tr>
<td></td>
<td>Extrinsic</td>
<td>87.826</td>
<td>3</td>
<td>29.275</td>
<td>1.695</td>
<td>.170</td>
<td>.031</td>
</tr>
<tr>
<td></td>
<td>Perform</td>
<td>591.611</td>
<td>3</td>
<td>197.204</td>
<td>4.336</td>
<td>.006**</td>
<td>.075</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>2183.619</td>
<td>3</td>
<td>727.873</td>
<td>3.103</td>
<td>.028*</td>
<td>.055</td>
</tr>
<tr>
<td>Style</td>
<td>Intrinsic</td>
<td>14.310</td>
<td>1</td>
<td>14.310</td>
<td>.591</td>
<td>.443</td>
<td>.004</td>
</tr>
<tr>
<td></td>
<td>Extrinsic</td>
<td>17.982</td>
<td>1</td>
<td>17.982</td>
<td>1.041</td>
<td>.309</td>
<td>.006</td>
</tr>
<tr>
<td></td>
<td>Perform</td>
<td>76.008</td>
<td>1</td>
<td>76.008</td>
<td>1.671</td>
<td>.198</td>
<td>.010</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>72.457</td>
<td>1</td>
<td>72.457</td>
<td>.309</td>
<td>.579</td>
<td>.002</td>
</tr>
<tr>
<td>Group * Style</td>
<td>Intrinsic</td>
<td>55.665</td>
<td>3</td>
<td>18.555</td>
<td>.767</td>
<td>.514</td>
<td>.014</td>
</tr>
<tr>
<td></td>
<td>Extrinsic</td>
<td>15.808</td>
<td>3</td>
<td>5.269</td>
<td>.305</td>
<td>.822</td>
<td>.006</td>
</tr>
<tr>
<td></td>
<td>Perform</td>
<td>17.687</td>
<td>3</td>
<td>5.896</td>
<td>.130</td>
<td>.942</td>
<td>.002</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>352.702</td>
<td>3</td>
<td>117.567</td>
<td>.501</td>
<td>.682</td>
<td>.009</td>
</tr>
</tbody>
</table>

Note. *p < .05. **p < .01. ***p < .001.

Another two-way ANOVA using Tukey as a post hoc test was conducted to examine the interactive effects between the experimental condition and cognitive style in each cognitive load rating (Table 5). The ANOVA source of variation results indicated no interaction effects regarding intrinsic load, \( F(3,161) = 0.767, p = 0.514, \) partial η² =
However, the main effect of the group treatment was statistically significant, $F(3,161) = 2.686, p = 0.048$. Those in the NSG ($M = 19.93, SD = 3.619$) had significantly higher intrinsic load than did those in the ASG ($M = 17.05, SD = 4.889$), $p = 0.042$ (Table 2). There were no interaction effects concerning extraneous load, $F(3,161) = 0.305, p = 0.822$, partial $\eta^2 = 0.006$. There were no interaction effects regarding performance load, $F(3,161) = 0.305, p = 0.942$, partial $\eta^2 = 0.006$. However, a main effect of the group treatment was statistically significant, $F(3,161) = 4.336, p = 0.006$. Those in the NSG ($M = 28.05, SD = 4.93$) had significantly higher performance load than did those in the SBG ($M = 23.47, SD = 8.11$), $p = 0.012$; SBSAG ($M = 23.91, SD = 7.24$), $p = 0.029$; and ASG ($M = 23.81, SD = 5.99$), $p = 0.025$ (Table 2). There were no overall interaction effects on cognitive load, $F(3,161) = 0.501, p = 0.682$, partial $\eta^2 = 0.009$. However, a main effect of the experimental treatment was statistically significant, $F(3,161) = 3.103, p = 0.028$. Those in the NSG ($M = 71.75, SD = 10.46$) had significantly higher overall cognitive loads than did those in the ASG ($M = 62.81, SD = 14.35$), $p = 0.043$ (Table 2).

**Discussion and conclusions**

**Research question one**

First, the learners’ performances indicated that those who received attention cueing failed to optimize their conceptual understanding and did not outperform those learners who did not receive attention cueing. The results somewhat echoed the results of previous studies (e.g., Crooks et al., 2012; de Koning et al., 2011a; Kriz & Hegarty, 2007; Lin & Atkinson, 2011; Moreno, 2007). One possible explanation is that merely providing attention cueing may only direct learners’ attention to the essential elements without guaranteeing that learners constructed accurate mental representations and enhanced conceptual understanding (de Koning et al., 2009; Harp & Mayer, 1998; Kriz & Hegarty, 2007). Secondly, providing verbal text may be sufficient for learners to construct mental imagery (Plass et al., 2003), with the addition of visual representations with attention cueing being redundant. When the verbal and visual representations presented the same information, the learners applied cognitive resources to process both the visual and verbal information and left the remaining resources unavailable for helpful information processing. Then, the information presented might be redundant (Hegarty et al., 2003; Imhof et al., 2013).

Secondly, those who received dynamic contrast cueing (i.e., ASG) did not significantly outperform those who received visual contrast cues (i.e., SBSAG). The results somewhat echoed the results of previous studies (e.g., Hegarty et al., 2003; Tversky, Morrison, & Bétrancourt, 2002) in which animation was not superior to static diagrams in promoting learning efficiency. Possibly learners focused more on the salient dynamic-blood-and-dynamic-arrow cues and less on the written text, resulting in limited integration of the visual and verbal representations. A second possible explanation is that the transiency of animation caused interference (e.g., Hegarty et al., 2003). The learners had to visually switch back and forth between the text and animation which may have caused them to miss some information (Hegarty et al., 2003; Johnson & Mayer, 2010).

Thirdly, the presence of integration cues failed to optimize conceptual understanding, but yielded similar performances in the matching and identification tests. Those who received integration cues were still unable to indicate the steps in blood circulation. It was possibly the diagrams on the tests were completely different from the pictures in the instrumentation, so the learners felt difficult to transfer what they had learned in their attempt to understand the flow of blood through the body.

**Research question two**

Generally speaking, those in the NSG had significantly higher cognitive loads than did those in the other three conditions. The results were somewhat in line with the studies of Amadieu et al. (2011) and Kalyuga et al. (1999), which showed that the presence of visual or dynamic contrast cues can help reduce mental loads as predicted.

Besides, those in the NSG did not report having a higher mental load when taking the retention test, which simply required them to recall what they had learned without requiring them to convert texts into images. However, they generally reported having a higher mental load when answering the pictorial recall, matching, and identification
tests, all of which involved pictures. The pictures used in the dependent measures were completely different from those in the instrumentation. The learners had no images to retrieve from the instrumentation when answering the imagery-based questions which required them to convert written texts into mental images. Therefore, performing these tasks was evidently more mentally demanding.

**Research question three**

The high-visualizers outperformed the low-visualizers in all four conditions, but did not reach the level of significance. There were no interaction effects between the experimental treatment and visual style in regard to the total score and overall cognitive loads, implying that both the high- and low-visualizers benefited equally well and experienced similar cognitive load from attention cueing. Further examination of the learners’ performance on each subcategory of the tests revealed that visual representation with animated cueing was redundant for the high-visualizers but probably compensated for the low-visualizers. Since the high-visualizers had strong cognitive abilities that better enabled them to construct mental animation, the dynamic contrast cues were likely redundant and caused interference. However, the dynamic contrast cues providing external representations helped the low-visualizers build up mental models (Höffler, 2010), develop greater conceptual understanding, and perform better (Höffler & Leutner, 2011; Höfler, 2010; Mayer, 2009). These findings were largely consistent with those of Hegarty et al. (2003) and Imhof et al. (2013), in which no interactive effects between experimental treatment and visual style were found. There was almost no evidence to suggest that attention cueing favors high-visualizers. Attention cueing probably plays no role when comparing both high- and low-visuospatial learners (Höffler, 2010).

In sum, regardless of learners’ cognitive styles, the presence of attention cueing yielded similar effects among all the learners, while reducing their cognitive load.

**Suggestions for future research**

No statistical evidence was observed to support the idea that attention cueing optimizes learning and benefits high-visualizers. Future researchers can replicate the experiment by incorporating self- or instructional explanations (de Koning et al., 2010b) or presenting the material with high- or low-speed (de Koning et al., 2011a) to examine learners’ learning efficiency.

**References**


Effects of Situated Mobile Learning Approach on Learning Motivation and Performance of EFL Students

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ABSTRACT

This study developed a 5-step vocabulary learning (FSVL) strategy and a mobile learning tool in a situational English vocabulary learning environment and assessed their effects on the learning motivation and performance of English as a foreign language (EFL) students in a situational English vocabulary learning environment. Overall, 80 EFL students and 1 teacher participated in this study. Two learning methods were implemented. The first involved employing the FSVL strategy and the mobile learning tool in a situational English vocabulary learning environment, and the other method involved employing the FSVL strategy and traditional learning tools in a situational English vocabulary learning environment. Data were collected by conducting interviews and tests and administering the Attention, Relevance, Confidence, and Satisfaction motivation questionnaire. The results showed that the learning motivation and performance of students taught using the FSVL strategy and mobile learning tool were superior to those of students taught using the FSVL strategy and traditional learning tools in a situational English vocabulary learning environment.

Keywords

Mobile learning, Situated learning, English vocabulary learning, Personalized learning

Introduction

Globalization has generated a trend toward learning English as a second language. Numerous students from non-English-speaking countries attend colleges, language schools, and institutes to learn English (Ballou, 2009; Liu & Chu, 2010). Several studies have shown that vocabulary plays a role as a necessary foundation in learning English (Sun, Huang, and Liu, 2011). Wilkins (1972) asserted that communication is possible without grammar but not without vocabulary. Oxford (1990) indicated that the major obstacle that English learners confront is the requirement that a large vocabulary must be memorized, and that English as a foreign language (EFL) students often learn vocabulary by rote (Kim & Gilman, 2008). In traditional teaching methods, teachers typically give students vocabulary textbooks and use the blackboard to demonstrate word spelling and invite students to practice writing words. A lack of situational assistance necessitates that EFL students memorize vocabulary by rote (Kim & Gilman, 2008). Thus, some researchers have proposed an alternative method—situated learning—to assist EFL students in learning vocabulary (Winn, 1993; Hay 1993).

Situated learning is when learners acquire knowledge and skills by performing activities in real, interactive situations; this enables them to rationally and meaningfully interpret the knowledge and skills acquired during such a process (Brown, Collins, and Duguid, 1989; McLellan, 1996). The new knowledge acquired by learners through situated learning is not isolated or fragmented but complete and comprehensive knowledge that is truly mastered following reorganization (Harley, 1993). Because of the limitations of traditional English teaching venues, situated learning cannot be adequately implemented. Therefore, numerous researchers have adopted situational teaching aids and multimedia technology to implement situated learning in teaching venues and establish a situational English classroom (Chen & Chung, 2008). Situational English classrooms are immersive and simulate real-life situations; they enable EFL students to learn English vocabulary that can be used in those situations. Numerous studies have shown that situated learning effectively improves the performance of EFL students in learning vocabulary (Winn, 1993; Hay, 1993; McLellan, 1996). However, some researchers have indicated that learning vocabulary in real situations rather than simulated situations enables students to develop a stronger sense of immediacy and, consequently, enhances learning motivation and outcomes. A mobile learning tool is an optimal aid for this type of learning (Sandberg, Maris, & de Geus, 2011; Liu & Chu, 2010).
To facilitate enhanced vocabulary learning performances among EFL students, novel learning aids must be integrated with effective vocabulary learning strategies (Herrington & Oliver, 2000). Brown and Payne (1994) proposed a 5-step vocabulary learning strategy (FSVL) that comprised the steps of encountering, getting, comprehending, consolidating, and using. This study adopted the FSVL strategy combined with a mobile learning tool featuring guiding, recording, and prompting functions to support situational English vocabulary learning environments. In a situational English vocabulary learning environment, the tool can be employed to assist EFL students in completing the learning steps of the FSVL strategy.

This study investigated the effects that the mobile learning tool and traditional learning tools exerted on the learning performance of EFL students given an identical vocabulary learning strategy and situational English vocabulary learning environment. In addition, regarding motivation theory, the empirical study provided evidence on how extrinsic motivation (EM) and intrinsic motivation (IM) are used in foreign language field (Noels, Pelletier, Clément, and Vallierand, 2000). Extrinsic motivation is related to achieving some intended goals, such as earning a reward or avoiding punishment. In contrast, intrinsic motivation (IM) refers to engaging in an activity which is enjoyable and fulfilling. Aarts & McMahon (2008) argued that students’ active motivation would push them to strive for better performance, achievement, and ability. Moreover, these studies believed that most of the research that has integrated mobile learning systems in their learning activities tend to focus more on the interaction between the students and the system and its effect on learning performance, but not focusing on students’ learning motivations and mental status (Alavi & Leidner, 2001). Palmer and Goetz (1988) believed that motivational beliefs are important factors that affect self-learning and that motivation is a key factor in helping students take responsibilities in learning. In addition to exploring learning performance, this research also studied and analyzed the learning motivation and learning attitude of the students. Two research questions for this study are stated as follows:

1. Based on the FSVL strategy, can using the mobile learning tool in a situational English vocabulary learning environment enhance EFL students’ motivation to learn English vocabulary?
2. Based on the FSVL strategy, can using the mobile learning tool in a situational English vocabulary learning environment enhance EFL students’ performance to learn English vocabulary?

**Literature review**

**Mobile learning**

Because of the development of mobile devices, mobile learning has proliferated in recent years. With mobile learning, learners are not limited to learning in a traditional classroom and can undertake digital learning activities at any place and time (Hwang & Tsai, 2011). Mobile learning is a flexible learning process, and researchers have variously defined the concept of mobile learning. Georgiev, Georgieva, and Smrikarov (2004) stated that learning can occur at any place and time and that using mobile devices to learn can expand the fields and scope of learning; mobile learning may thus be considered an extension of online learning. According to Chen and Hsu (2008), mobile learning means that with the digital content of mobile devices, learners can undertake learning activities at any time and place. This breakthrough in digital learning was possible because of the 5 characteristics of mobile devices (Klopfer & Squire, 2008): portability, social interactivity, context sensitivity, connectivity, and individuality. Portability means that mobile devices can be transported into any area and are movable within that area. Social interactivity means that face-to-face information exchanges or cooperation with other people are feasible. Context sensitivity means that localized information (including time and place) can be acquired. In other words, both real and virtual information can be collected to provide location-based information or services (Tan, Lin, Chu, & Liu, 2012). Connectivity means that mobile devices can be connected and collect information from one another, and that networked information-sharing environments can be created. Individuality means that mobile devices can provide learners with independent scaffolding, allowing them to learn at their own pace. By integrating other learning theories (e.g., scaffolding learning theory), learning content can be diverse and comprehensive (Huang, Huang, Huang, and Lin, 2012; Hsu, Hwang, & Chang, 2013).

**Situated learning**

The concept of situated learning originates from human psychology research. Suchman (1987) observed how people learned to operate a photocopying machine and found that learners typically learned through trial-and-error rather
than by reading the manual prior to attempting operation. Therefore, Suchman (1987) proposed that practical learning experiences are necessary for knowledge construction, and that continual interaction in real situations enables people to establish personal representations of knowledge. Brown, Collins, and Duguid (1989) proposed the concept of situated cognition and argued that knowledge construction is affected by culture, activities, and environments. Knowledge is only meaningful in productive situations, or situations in which that knowledge can be applied. Situated learning can be understood in the context of school learning activities. Situated learning means that in specific situations, people acquire effective strategies to solve problems in that situation by continually interacting in that situation.

According to situated learning theory, situated learning occurs in real situations: learners must acquire comprehensive knowledge and establish the meaningfulness and framework of that knowledge by interacting with others in real situations (Collins, 1991). Situated learning enables learners to avoid learning isolated or fragmented knowledge and allows them to apply this knowledge in daily life. Situated learning theory emphasizes the importance of the “person-plus-the-surroundings” concept, where the “surroundings” include learning environments, activities, and peers. Learning is a process during which knowledge is organized and its meaningfulness is established. Learners are active organizers in a learning environment, and knowledge is the result of interaction between learners and their surroundings (Anderson, Reder, & Simon, 1996).

**Mobile learning tool**

**System design**

In this work, we aimed to develop a mobile learning tool for the purpose of providing support to students engaging in the FSVL process. To this end, GPS technology and semantic similarity rule were used to develop a tool. GPS technology is able to sense the situation of students and provide them with appropriate learning material in real-world contexts (Hwang, Tsai, Chu, Kinshuk, & Chen, 2012). Semantic similarity rule is able to find specific words and also offer their definitions (Huang, Yang, & Su, 2012). When arriving a situation, the tool starts the semantic similarity rule and finds possible situated words from its knowledge base. Initially, the tool used an ontology-based Open Directory Project (ODP) hierarchy to generate the domain knowledge structure to the knowledge base for vocabulary profile. Based on the ODP hierarchy, the semantic similarity ($\text{sim}_{\text{word}}$) between the coordinates of situation $s_t$ and the words of vocabulary $v_t$ stored in the knowledge base is calculated by

$$\text{sim}_{\text{word}}(s_t, v_t) = \begin{cases} e^{-\alpha l}e^\beta h - e^{-\beta h} & \text{if } s_t \neq v_t \\ 1, & \text{Otherwise} \end{cases}$$  \hspace{1cm} (1)

If the height of $s_t$ in the ODP hierarchy is represented by $h_1$ and the height of $v_t$ in the ODP hierarchy is represented by $h_2$, the $h$ determines the minimum value between $h_1$ and $h_2$ and the $l$ determines the shortest path between $s_t$ and $v_t$. Additionally, $\alpha$ and $\beta$ represent ranking control parameter for $l$ and $h$. Based on (1), this study obtains the semantic similarity ($\text{sim}_{\text{word}}$) and determines the word display rate ($WDR$) of word using the knowledge base. Equation (2) then calculated the rank value of each word using semantic similarity and word display rate ($WDR$), while using variables $a$ and $b$ to achieve a flexible match result (Huang, Yang, & Su, 2012). Variable $a$ represents the proportion of word display rate, while variable $b$ represents the proportion of semantic similarity. The results are used to rank the word of vocabulary. According to the level of rank, the tool is adjusted to arrange the order of word presented. The tool only presents highest-ranking words in the situation environment.

$$\text{Rank} = \frac{a \times WDR + b \times WDR}{(a + b)} \text{ or } \frac{WDR + \text{sim}_{\text{word}}}{2}$$  \hspace{1cm} (2)

Figure 1 shows the framework of the mobile learning tool, which is a standard client-server framework. The server is mainly a database that is used to store the design of the learning activity and the teaching material. The client involves both a teacher application and a student application. The teacher application enables teachers to design a learning activity in which they can use the application to arrange the learning location, the teaching material to be learned that can assist students. The student application enables students to perform a learning activity in which they
can use a mobile device with the application to engage in the learning activity. The mobile device is equipped global positioning system receiver to sense the location of the students involved in the process. Finally, the tool is able to provide students with learning material according to their situation.

System demonstration

First, using the mobile learning tool, students are guided to an outdoor learning site through a navigation interface. With the tool, red dots presented on a map indicate various outdoor learning sites to learners. When a learner chooses an outdoor learning site, the tool shows the location and direction of the outdoor learning site, as well as the distance between the learning site and the learner. After the learner arrives at the site with the guidance of the tool, an assistive device presents a conversation related to the site, as shown in Figure 2. Accordingly, students can experience the encountering phase of the FSVL strategy.

Additionally, to assist students with learning the forms of new words, the tool displays the new words that can be learned from the situation. They can experience both the getting and understanding phases of the FSVL strategy.
When the user presses the red trumpet icon displayed in the interface, an assistive device pronounces the word and provides an input column for learners to input the meaning using Chinese characters. This function tests whether learners can guess the Chinese meanings of words by hearing them pronounced. Subsequently, an assistive device displays example sentences related to these new words and presents an input column for learners to input the meaning using Chinese characters. This function examines whether learners can understand the meanings of new words based on the context, as shown in Figure 3.

Next, the tool displays the correct meanings of the words and provides example sentences. Students can use the buttons (i.e., “previous” and “next”) and the scroll bar provided at the top of the screen to toggle between words. Furthermore, a menu on the screen offers the option to perform the following 6 sub functions: (a) “next situation” to switch between words, (b) “online guide” to hear the pronunciation of words and obtain example sentences to train listening ability, (c) “Google translate” to show translations provided by Google, (d) “online dictionary” to obtain Internet information and resources, (e) “oral practice” to use an assistive device to assess whether words have been correctly pronounced to train second-language speaking ability, and (f) “automatic play/stop” to automatically toggle between words for occasions when learners cannot manually switch between words, as shown in Figure 4.
The tool displays a dialogue typical of the situation and enables students to practice that dialogue with their peers in a particular situation, namely, to experience the consolidating phase, as shown in Figure 5. Finally, students repeat the dialog aloud in order to experience the using phase and the situational vocabulary learning activity is concluded when learners press the “finish” button.

Research methods

Participants

The study participants comprised 80 fourth grade students at an elementary school located in Northern Taiwan. The participants ranged between 9 and 10 years of age and were recruited from two classes. One class served as the experimental group and the other class served as the control group. The two classes were taught by the same teacher. Next, both the experimental and control groups were divided into several subgroups that each comprised three students (i.e., one high-learning-ability student, one medium-learning-ability student, and one low-learning-ability student). According to the results of a pretest, students that ranked above the 67th percentile were considered high-learning-ability students, students that ranked below the 33rd percentile were considered low-learning-ability students, and the remaining students were considered medium-learning-ability students.

Measurement tools

Pretest quiz design

The pretest quiz employed in this study was designed by senior teachers. The pretest quiz comprised 10 multiple-choice questions regarding English to Chinese translations and 10 multiple-choice questions regarding the example sentences. The highest possible score for each question was 5 points, and the total possible score for the pretest quiz was 100 points. The contents of the pretest quiz involved everyday vocabulary. The purpose of the pretest quiz was to assess the students’ prior knowledge of basic English vocabulary. Some of the questions included in the pretest quiz are presented in Figure 6.
Posttest quiz design

The posttest quiz employed in this study was designed by senior teachers. The posttest quiz comprised 10 multiple-choice questions regarding English to Chinese translations and 10 multiple-choice questions regarding the example sentences. The highest possible score for each question was 5 points, and the total possible score for the pretest quiz was 100 points. The contents of the posttest quiz involved learning situations experienced in the course of the learning activities. The purpose of the posttest quiz was to detect the students’ learning performance at the end of learning activities. Some of the questions included in the posttest quiz are presented in Figure 7.
Learning motivation questionnaire

This study employed a motivation questionnaire based on the Attention, Relevance, Confidence, and Satisfaction (ARCS) motivation model developed by Keller (1987) to analyze learners’ motivation. The ARCS model are premised on the following principles: the design of learning activities must attract learners’ attention; learning activities or materials must have relevance to learners; learners’ confidence in learning must be established; and learners must gain satisfaction from learning at the end of the learning process. This questionnaire comprised 17 questions. Responses to all questions were on a fivepoint Likert-scale, from 5 for “strongly agree” to 1 for “strongly disagree.” Regarding questionnaire reliability, this study used Cronbach’s alpha (α) to assess the internal consistency of the questionnaire. The Cronbach’s α for each sub-dimensions was 0.82, 0.83, 0.82, and 0.84, respectively, and for the questionnaire was 0.86. The Cronbach’s α was required to exceed 0.80 for all questionnaire dimensions to indicate superior reliability.

Experimental procedures

The experimental group was taught to use the mobile learning tool for 20 min. Subsequently, both the experimental and control groups were allocated 30 min to complete the pretest quiz before the courses for the experimental and control groups were initiated. For the experimental group, the FSVL strategy combined with the mobile learning tool were employed in a situational English vocabulary learning environment. The first stage was “encountering,” which spanned 20 min. During this stage, the students were guided by the mobile learning tool to an outdoor learning site. The second stage was “getting,” which spanned 20 min. In this stage, the students used the mobile learning tool to learn new vocabulary. The third stage was “comprehending,” which spanned 10 min. During this stage, the students used the mobile learning tool to understand the meaning of new vocabulary by using Chinese characters. The fourth stage was “consolidating,” which spanned 50 min. For this stage, the students used the dialogue provided by the mobile learning tool to practice speaking English. Finally, the fifth stage was “using,” which spanned 50 min. In this stage, the students practiced speaking English using dialogue typical of specific situational roles, such as front desk staff. Finally, all learning activities for the experimental group were concluded.

Figure 8. Diagram of experimental procedure
For the control group, the FSVL strategy combined with traditional learning tools were employed in a situational English vocabulary learning environment. The first stage of encountering spanned 30 min. During this stage, the teacher presented a conversation transcript in the situational English classroom. The second stage of getting spanned 50 min. In this stage, the teacher instructed the students to identify new words related to the situational English classroom and conversation transcript. The teacher also played the CD recording of the pronunciations of new words and instructed the students to practice pronouncing the new words. The third stage of comprehending spanned 20 min. The teacher instructed the students to find the new words in a dictionary and learn the Chinese equivalents of the words and relevant example sentences. The fourth stage of consolidating spanned 50 min. The teacher instructed the students to practice using the example sentences provided in the conversation transcript and the learning tools in the situational English classroom. Finally, during the fifth stage of using, the teacher presented other conversation transcripts related to restaurant situations.

After completing all learning activities, we administered a post learning test and the ARCS motivation questionnaire to the experimental and control groups for 50 min to assess the students’ learning performances and motivation. In addition, this study randomly selected students from each group to complete a 50 min qualitative interview, after which the experiment procedure was concluded. The learning activities adopted for the experiment procedure are presented in Figure 8.

**Experimental results**

**Analysis of learning performance**

Before the paired samples $t$-test was performed, the homogeneity of the variances among the pretest scores was examined. An independent samples $t$-test was also performed to assess the homogeneity of variances; the results were insignificant, indicating that the pretest scores for the two groups did not differ significantly. Thus, paired samples $t$-tests were performed regarding the differences between the pretest and posttest scores of the experimental and control groups; the results are presented in Table 1.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Pretest</th>
<th>Posttest</th>
<th>The difference of pretest and posttest</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>Mean</td>
<td>$N$</td>
</tr>
<tr>
<td>Experimental group</td>
<td>71.13</td>
<td>82.38</td>
<td>40</td>
</tr>
<tr>
<td>Control group</td>
<td>71.50</td>
<td>72.38</td>
<td>40</td>
</tr>
</tbody>
</table>

*Note. $^*$ $p < .05$.

The average pretest scores for both groups were extremely similar, and exhibited a difference of only 0.38. After all the learning activities were completed, the average posttest score for the experimental group was 82.38, and the difference between the variables was 11.25; the average posttest score for the control group was 72.38, and the difference between the variables was 0.88. According to the results of the paired samples $t$-tests, the experimental group exhibited a significant improvement following the mobile learning tool intervention ($t = -6.71, p < .05$). By contrast, the control group did not exhibit significant improvements after performing the learning activities ($t = -0.50, p > .05$).

For ANCOVA, the pretest scores were used as covariates. Before performing ANCOVA, the homogeneity of variances for covariance was examined. This study conducted an independent samples $t$-test to examine the homogeneity of variances for covariance; the results were insignificant ($p > .05$), indicating that the covariance was homogeneous. An ANCOVA analysis was subsequently performed; the results are presented in Table 2.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Group</th>
<th>$N$</th>
<th>Mean</th>
<th>$SD$</th>
<th>Adjusted mean</th>
<th>$F$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Posttest</td>
<td>Experimental group</td>
<td>40</td>
<td>82.38</td>
<td>15.81</td>
<td>83.37</td>
<td>14.11*</td>
</tr>
<tr>
<td></td>
<td>Control group</td>
<td>40</td>
<td>72.38</td>
<td>20.38</td>
<td>71.24</td>
<td></td>
</tr>
</tbody>
</table>

*Note. $^*$ $p < .05$.  

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According to the ANCOVA analysis results, a significant difference existed between the experimental and control groups regarding the learning performance shown in the posttests \((F = 14.11, p < .05)\). An LSD test revealed that the experimental group scores were significantly higher than those of control group, comparing the adjusted mean of 83.37 for the experimental group with the control group score of 71.24 \((p < .05)\). Therefore, the learning performance of the experiment group who adopted the FSVL strategy combined with the mobile learning tool in a situational English vocabulary learning environment exhibited a significant improvement.

### Analysis of learning motivation

This study explored whether applying the FSVL strategy and mobile learning tool in a situational English vocabulary learning environment enhanced students’ motivation to learn English vocabulary. After performing the assigned learning activities, the two groups of students were required to complete the ARCS motivation questionnaire. The data analysis results are presented in Table 3.

<table>
<thead>
<tr>
<th>Item</th>
<th>Experiment group ((N = 40))</th>
<th>Control group ((N = 40))</th>
<th>(t) of each item</th>
<th>(t) of dimension</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1</td>
<td>3.83 ± 0.75</td>
<td>3.75 ± 0.95</td>
<td>0.39</td>
<td></td>
</tr>
<tr>
<td>A2</td>
<td>4.03 ± 0.77</td>
<td>3.43 ± 0.78</td>
<td>3.47</td>
<td></td>
</tr>
<tr>
<td>A3</td>
<td>3.95 ± 0.68</td>
<td>3.33 ± 0.76</td>
<td>3.87</td>
<td></td>
</tr>
<tr>
<td>A4</td>
<td>3.73 ± 0.72</td>
<td>3.68 ± 0.76</td>
<td>0.30</td>
<td>2.73</td>
</tr>
<tr>
<td>A5</td>
<td>3.63 ± 0.67</td>
<td>4.15 ± 0.77</td>
<td>-3.26</td>
<td></td>
</tr>
<tr>
<td>A6</td>
<td>4.08 ± 0.80</td>
<td>3.48 ± 0.82</td>
<td>3.33</td>
<td></td>
</tr>
<tr>
<td>A7</td>
<td>4.05 ± 0.78</td>
<td>3.45 ± 0.85</td>
<td>3.29</td>
<td></td>
</tr>
<tr>
<td>R1</td>
<td>3.58 ± 0.71</td>
<td>3.48 ± 0.82</td>
<td>0.58</td>
<td></td>
</tr>
<tr>
<td>R2</td>
<td>3.88 ± 0.69</td>
<td>3.78 ± 0.73</td>
<td>0.63</td>
<td>1.26</td>
</tr>
<tr>
<td>R3</td>
<td>3.83 ± 0.81</td>
<td>3.73 ± 0.64</td>
<td>0.61</td>
<td></td>
</tr>
<tr>
<td>R4</td>
<td>4.10 ± 0.74</td>
<td>3.53 ± 0.82</td>
<td>3.29</td>
<td></td>
</tr>
<tr>
<td>C1</td>
<td>3.75 ± 0.63</td>
<td>3.73 ± 0.76</td>
<td>0.16</td>
<td></td>
</tr>
<tr>
<td>C2</td>
<td>3.75 ± 0.63</td>
<td>3.68 ± 0.83</td>
<td>0.46</td>
<td>1.05</td>
</tr>
<tr>
<td>C3</td>
<td>3.83 ± 0.64</td>
<td>3.35 ± 0.83</td>
<td>3.39</td>
<td></td>
</tr>
<tr>
<td>C4</td>
<td>3.68 ± 0.73</td>
<td>3.65 ± 0.86</td>
<td>0.14</td>
<td></td>
</tr>
<tr>
<td>S1</td>
<td>4.18 ± 0.71</td>
<td>3.63 ± 0.70</td>
<td>3.47</td>
<td>3.2</td>
</tr>
<tr>
<td>S2</td>
<td>3.95 ± 0.85</td>
<td>3.35 ± 0.98</td>
<td>2.94</td>
<td></td>
</tr>
</tbody>
</table>

**Note.** \(^*p < .05\).

Regarding the ARCS motivation questionnaire, Questions 1 to 7 were related to the attention dimension of the ARCS motivation model and were used to assess the students’ attention to learning materials and activities. According to the results related to A1, no significant difference existed between the experimental and control groups regarding students’ attention to learning materials \((t = 0.39, p > .05)\). According to the results related to A2, the experimental and control groups differed significantly regarding the influence that the methods for presenting learning materials exerted on the students’ attention \((t = 3.47, p < .05)\). According to the results related to A3, a significant difference existed between the experimental and control groups regarding the self-initiative generated by the learning activities \((t = 3.87, p < .05)\). According to the results related to A4, no significant difference existed between the experimental and control groups regarding the influence of the method used to undertake learning activities on the students’ attention \((t = 0.30, p > .05)\). According to the results related to A5, a significant difference existed between the experimental and control groups regarding the students’ concentration abilities when performing learning activities \((t = -3.26, p < .05)\). According to the results related to A6, a significant difference existed between the experimental and control groups regarding the curiosity stimulated by learning activities \((t = 3.33, p < .05)\). According to the results related to A7, a significant difference existed between the experimental and control groups regarding students’ interest in learning activities \((t = 3.29, p < .05)\).
Questions 8 to 11 of the questionnaire were related to the relevance dimension of the ARCS motivation model and were used to assess whether the learning activities and materials were relevant to the learners. According to the results related to R1, no significant difference existed between the experimental and control groups regarding the students’ views concerning the relevance of the courses and their knowledge \((t = 0.58, p > .05)\). According to the results related to R2, no significant difference existed between the experimental and control groups regarding the students’ views concerning the relevance of the courses and daily life \((t = 0.63, p > .05)\). According to the results related to R3, no significant difference existed between the experimental and control groups regarding the students’ views concerning whether the courses were worth participating in \((t = 0.63, p > .05)\). According to the results related to R4, a significant difference existed between the experimental and control groups regarding the students’ views of whether the learning activities were helpful \((t = 0.63, p > .05)\).

Questions 12 to 15 of the questionnaire were related to the confidence hypothesis in the ARCS motivation model and were used to assess the students’ confidence and expectations regarding the learning activities. According to the results related to C1, no significant difference existed between the experimental and control groups regarding the students’ views of whether the learning activities met their expectations \((t = 0.16, p > .05)\). According to the results related to C2, no significant difference existed between the experimental and control groups regarding effectiveness in undertaking learning activities \((t = 0.46, p > .05)\). According to the results related to C3, a significant difference existed between the experimental and control groups regarding the students’ confidence in completing all learning activities \((t = 3.39, p < .05)\). According to the results related to C4, no significant difference existed between the experimental and control groups regarding their confidence in applying what they had learned to daily life \((t = 0.14, p > .05)\).

Questions 16 and 17 of the questionnaire were related to the satisfaction hypothesis in the ARCS motivation model and were used to assess learner satisfaction after completing the learning activities. According to the results related to S1, a significant difference existed between the experimental and control groups regarding the students’ views concerning whether the situated learning activities were enjoyable \((t = 3.47, p < .05)\). According to the results related to S2, a significant difference existed between the experimental and control groups regarding the students’ views concerning whether the situated learning activities were satisfactory \((t = 2.94, p < .05)\).

**Discussion and conclusion**

This study implemented a teaching experiment in a situational English vocabulary learning environment with two learning methods: one involved the FSVL strategy and the mobile learning tool, and the other learning method involved the FSVL strategy and traditional learning tools. Overall, 80 elementary school students and one teacher participated in the teaching experiment. Subsequently, the ARCS motivation questionnaire and a learning performance test were administered to the students before interviews were conducted.

Regarding learning performance, the experimental group exhibited significant improvement. The experimental group indicated that the functions of the mobile learning tool, such as automatically searching for new words and providing the meanings of new words, enabled the students to focus on understanding the meaning of new words and remembering new words without reference to a textbook or dictionary. The mobile learning tool could retrieve words and enable students to learn words at any time and place and discussed among them how to use the new words in real situations. Consequently, the experimental group actively learned the words presented by the mobile learning tool regardless of whether they were performing designated learning activities. Such as those reported by Liu, Chen, and Chang (2010), Jia, Chen, Ding, and Ruan (2012) that pointed to provide more interesting learning environments for students to gain knowledge and those that mainly use mobile learning tool for promoting students’ learning motivation (Sandberg, Maris, & de Geus, 2011; Liu & Chu, 2010). Furthermore, the low-learning-ability students rapidly understood that their learning progress lagged behind that of the other students and endeavored to improve themselves with assistance from the high-learning-ability students. By assisting the low-learning-ability students, the high-learning-ability students reviewed the vocabulary they had previously learned and clarified their understanding of word meanings and appropriate usages. As demonstrated in this study, most students consider integrated FSVL strategy with mobile learning tool to be a novel learning method. Using this method, the students who participated in this study did not learn by rote but instead learned step-by-step according to their own pace. In addition, through interaction in real situations, the students clearly understood and remembered the learned vocabulary. Because of group cooperation, the low-learning-ability students could rapidly understand whether their learning progress lagged...
behind that of the other students and endeavor to improve themselves with assistance from the high-learning-ability students. By assisting the low-learning-ability students, the high-learning-ability students reviewed the vocabulary learned and clarified their understanding of the word meaning and appropriate usages. According to the interview results, they could learn a substantial amount of everyday vocabulary in real situations at any time, and could learn how to use a word appropriately. For the experimental group, this learning method was interesting and enjoyable. These students were willing to apply this learning method to other subjects. Such a finding conforms to what has been reported by some previous studies that use conventional computer environments (Chen, Man, Yen, Jin, & Shih, 2010). This also reveals that the situated mobile language learning approach not only advantaged the students from the aspect of learning at anytime, but also enhanced them in terms of learning performance and efficiency.

Regarding learning motivation, among the 17 questions, the t-test results yielded significant results for 9 questions. Significant differences in the attention and satisfaction dimensions existed between the experimental and control groups.

Regarding attention dimensions, we found that when the experimental group performed the learning activities, the guidance and prompting functions of the mobile learning tool enabled the students to complete the required tasks at every FSVL stage. For example, at the stage of encountering, the tool rapidly guided the students to a learning site and enabled the students to focus on the learning activities. The control group indicated that guidance from the teacher prevented them from becoming distracted from the learning activities performed in the situational English classroom. However, both groups found that the developed learning materials did not differ substantially from previous learning materials, and were easier than previous learning materials. The reason for this result was that most of the students in the two groups had previously learned English in after-school classes and were therefore capable of learning a greater amount of everyday English vocabulary. Additionally, the experimental group indicated that distractions such as outdoor noise hindered their performance in learning activities. These students were unable to consistently concentrate on the learning activities. By contrast, the control group was able to learn in a situational English classroom without external hindrances. Regarding satisfaction dimensions, the experimental group asserted that the mobile learning tool was easy to use and useful. When not performing formal learning activities, the students would use the mobile learning tool to learn and practice new vocabulary in their spare time. This is an interesting finding. Teachers in general have to get used to the idea that the school is not the only place for learning and they have to be willing to recognize that the value of non-formal and informal learning. One way to enhance teachers’ views on informal learning is to engage them in the informal learning process (Mifsud, 2002; Sharples, 2000).

Concerning the other 8 questions, the t-tests yielded insignificant results, which accorded with the findings reported by Liu and Chu (2010). These 8 questions mostly pertained to teaching materials. This study found that the learning approach did not significantly affect students’ motivation to learn the teaching materials. Regarding relevance dimensions, the high- and medium-learning-ability students in the experimental and control groups considered the course content relevant. Because they had learned most of the words in after-school classes, they did not think that additional time learning the same words was warranted. By contrast, the low-learning-ability students in both groups asserted that the course materials (e.g., the words “cup” and “drink”) were highly relevant to daily life and that the course materials were worth learning (Tozcu & Coady, 2004; Ogata & Yano, 2004; McLellan, 1996). Therefore, no significant difference existed between the two groups regarding their views concerning the relevance of the learning materials for learners. Regarding confidence dimensions, the medium- and high-learning-ability students in the experimental group indicated that they felt that the learning activities differed considerably from traditional learning approaches. However, they had developed their own learning approaches such as reciting vocabulary and image mnemonics, and that therefore, their expectations for the new method were low (Chen & Chung, 2008). The low-learning-ability students in the experimental group reported that the novel learning approach was unusual and not as uninteresting as learning vocabulary. The novel learning approach increased the appeal of learning or reciting vocabulary and satisfied the students’ expectations.

For future research, the design of learning activities for the relevance and confidence dimensions of the ARCS motivation model should be improved. Additionally, how to retain students’ motivation to learn English vocabulary should be investigated. We anticipate that additional technologies related to augmented reality, context awareness, and physiological awareness that can be applied to other subjects and situations will be developed in future studies.
Acknowledgements

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References


Alexander Meets Michotte: A Simulation Tool Based on Pattern Programming and Phenomenology

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ABSTRACT
Simulation and modeling activities, a key point of computational thinking, are currently not being integrated into the science classroom. This paper describes a new visual programming tool entitled the Simulation Creation Toolkit. The Simulation Creation Toolkit is a high level pattern-based phenomenological approach to bringing rapid simulation creation into the classroom environment. Students create agent-based simulations via analogy between the real world phenomena they are trying to represent and “interacticons,” which are visual animations of generic agents enacting the phenomena. This approach obviates the need for students to implement low level and often time-consuming agent behavior programming and yet, requires the use of abstraction, which is a key component of computational thinking. Initial data shows that students in the classroom can implement simulations faster using the Simulation Creation Toolkit as compared to the end-user programming level and begins to show that students can use the Simulation Creation Toolkit to create simulations through analogical reasoning. In this sense, Simulation Creation toolkit provides an initial data point into the integration of Computational Thinking activities through simulation construction in the classroom environment.

Keywords
Computational thinking, Computational thinking patterns, Pattern based visual languages, Phenomenology, STEM education, Simulation creation

Introduction
Educational end-user game programming tools
Many educational visual programming tools are aimed at lowering the barrier of entry into computer science for end-users (Kelleher & Pausch, 2005). These tools often deemphasize syntax by enabling rule-based programming through drag and drop interfaces. Evidence shows that this strategy is successful at motivating students in the area of computer science (Kelleher & Pausch, 2005; Squire, 2003).

Figure 1. The top picture shows a depiction of the Lobster Agent, the bottom pictures shows one rule of the Lobster Agent’s behavior which uses a “Key Pressed” condition and a “Move” action
For example, a tool we currently employ at the University of Colorado Scalable Game Design Lab is AgentCubes. AgentCubes is an agent-based rapid end-user game and simulation prototyping tool (Repenning, 2011). In AgentCubes, users can quickly create 3D games consisting of agents, which are the in-game characters. Each agent contains a depiction of how it looks and behaviors that are the set of rules that dictate its action throughout the game run. Agent behaviors rely on if/then conditionality rules wherein each rule has 2 parts: an “if” part containing conditions and a “then” part containing actions. AgentCubes currently provides users with a palette of 14 different conditions and 36 different actions that users can combine to create different agent behaviors. Figure 1 depicts a Lobster agent with one behavior rule that moves the lobster to the right when the right arrow key is hit. Previous research has shown that students can go from no prior programming experience to making their first game, Frogger, in 5 hours using AgentCubes (Repenning, Webb, & Ioannidou, 2010).

**How end-user game programming relates to computational thinking and simulation design**

In addition to motivating students through game design, many educational end-user programming tools also have the potential to enable “computational thinking” (Repenning, Webb, & Ioannidou, 2010). At present time, computational thinking is defined to include the following six items: problem formulation, logically organizing and analyzing data, representing data through abstractions such as models, automating solutions through algorithmic thinking, implementing effective solutions optimally, and transferring solutions to solve a large variety of problems (Barr, Harrison, & Conery 2011).

Enabling simulation and modeling activities is a means by which these tools can facilitate computational thinking in the classroom. Jeanette Wing, former Assistant Director of the National Science Foundation and a major proponent of computational thinking, states the following:

“The abstraction process—deciding what details we need to highlight and what details we can ignore—underlies computational thinking” (Wing, 2008).

In creating representational systems of real world phenomena, users choose which aspects of the real world to model based on what problem they are attempting to solve or gain insight into. Ideally, computational thinking can be achieved by enabling a user to take a problem from the real world, create a representation of this problem using an end-user programming tool, and run experiments while altering simulation parameters to get a better understanding of the real world concept being studied.

**Computational thinking patterns**

In an attempt to formalize the link between game design and simulation creation, we have come up with a construct entitled “Computational Thinking Patterns.” Computational Thinking Patterns are agent behaviors users initially learn in game design but transfer to agent behaviors used in simulations (Basawapatna, Koh, Repenning, Webb, & Marshall, 2011). In this respect, Computational Thinking Patterns can be thought of as the “units of transfer” between game and simulation design. For example, in the game Pacman, users might learn the tracking pattern implementation to enable Ghost agents to chase after the Pacman agent. Similarly, in a predator/prey simulation a user might use the tracking pattern to have a hungry Fox agent chase after a Rabbit agent.

Computational Thinking Patterns elucidate the low-level if/then conditionality behaviors necessary in implementing various agent interactions. Table 1 lists some Computational Thinking Patterns relevant to this paper. A more exhaustive list with specific examples can be found in (Basawapatna, Koh, Repenning, Webb, & Marshall, 2011).

Previous research has shown that when users learn a given Computational Thinking Pattern in a game context, they can effectively identify this same pattern in other contexts (Basawapatna, Koh, Repenning, Webb, & Marshall, 2011). Furthermore, there is ongoing current research dedicated to assessing games through the identification of the Computational Thinking Patterns contained within (Koh, Basawapatna, Bennett, & Repenning, 2010).
Table 1. Example computational thinking patterns

<table>
<thead>
<tr>
<th>Pattern</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Change</td>
<td>One agent changes into another agent.</td>
</tr>
<tr>
<td>Absorb</td>
<td>One agent makes another agent disappear.</td>
</tr>
<tr>
<td>Transport</td>
<td>One agent transports another agent.</td>
</tr>
<tr>
<td>Push</td>
<td>One agent pushes another agent.</td>
</tr>
<tr>
<td>Random movement</td>
<td>An agent moves randomly.</td>
</tr>
<tr>
<td>Tracking</td>
<td>One agent chases another agent.</td>
</tr>
<tr>
<td>Keyboard movement</td>
<td>Keyboard button presses control an agent’s movement.</td>
</tr>
<tr>
<td>Directional movement</td>
<td>An agent moves in a single direction at a certain speed.</td>
</tr>
<tr>
<td>Generate</td>
<td>One agent creates another agent.</td>
</tr>
<tr>
<td>Data</td>
<td>Counts the number of agents in existence at a particular instance of a simulation run.</td>
</tr>
</tbody>
</table>

Present barriers to classroom simulation and modeling activities/motivation for a new tool

At the present time there are many government and non-government organizations promoting computational thinking integration into the classroom environment. Organizations such as the President’s Council On Technology, the National Science Foundation, the Computer Science Teachers Association, the Next Generation Science Standards as well as third party groups such as the Shodor Foundation all endorse integrating aspects of computational thinking and specifically, simulation and modeling activities, into middle and high school classrooms (Basawapatna, 2012). Given the availability of accessible end-user programming tools, one might suspect that classrooms are already integrating simulation and modeling activities. However, this is not the case. A 2009 report by the U.S. Department of Education stated, in a combined category of computers/math/science, that 75% of classes rarely or never partake in in-class simulation or modeling activities (Gray, Thomas, Lewis, & Tice, 2010). This sentiment is echoed by the National Science Foundation, which states that it is increasingly difficult to integrate computer related activities in “already overburdened K-12 curriculums” (NSF Press Release, 2009).

For example, through the Scalable Game Design project at CU Boulder, we have instructed a number of teachers leading to more than 20,000 submitted student projects. These projects include games such as Frogger and simulations such as epidemiology and predator/prey. In two separate high school classrooms, we have observed that predator/prey, for example, takes one and half to two weeks to program (assuming a 50 minute class period). This includes the time it takes to gain sufficient programming skills to create the predator/prey simulation (Basawapatna, 2012). For a computer science class, with access to a computer lab, this is an acceptable amount of time to enable students with little or no prior programming experience to create simulations. However, for a Life Science class in which the emphasis is not learning the intricacies of programming, this time and resource commitment is often prohibitive.

A method to enable more rapid in-class simulation and modeling activities while preserving computational thinking could reduce the barrier to entry into Life Science and other non-computer lab based classes. Computational Thinking Patterns, in the context of AgentCubes programming, provide a higher-level pattern-based programming construct that could accomplish this goal. Currently, if students want to implement Computational Thinking Patterns, they have to do it at the low rule-based level. For example, if a student wants to implement a Fox agent tracking a Rabbit agent, they first program the Rabbit agent behaviors to emit a scent value, then have a Background agent diffuse this scent value through a complex diffusion equation, and finally implement a hill climbing algorithm in the Fox agent behaviors such that the Fox agent moves towards the highest Rabbit agent scent value each time it moves. Though undeniably educational, in a Life Science class, for example, implementing the math necessary to have a Fox agent chase a Rabbit agent is not relevant to the predator/prey unit being studied in class. In fact, students have already made the necessary abstraction at the point of pattern implementation—namely the Fox agent tracks the Rabbit agent. If instead there existed a mechanism such that students could specify the agents present in the tracking interaction, and the underlying if/then conditionality rules were automatically added, it could save time and yet preserve the computational thinking abstraction aspects of the simulation construction activity.

The remainder of this paper will describe the Simulation Creation Toolkit that is a first attempt at such a system. The Simulation Creation Toolkit is built on top of the AgentCubes environment, and affords users the ability to create simulations at the higher Computational Thinking Pattern level directly through analogy with the real-world phenomena they are modeling.
The simulation creation toolkit

Design principles

The aim of the Simulation Creation Toolkit is to enable users to more easily create simulations by defining behaviors at the Computational Thinking Pattern level as opposed to the lower if/then conditionality statements level. The development of this toolkit follows the four general design principles outlined in Table 2 allowing for easy student use.

<table>
<thead>
<tr>
<th>Number</th>
<th>Design principles</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>User should be able to intuitively select from a variety of patterns</td>
</tr>
<tr>
<td>2</td>
<td>Patterns should be customizable for a large variety of purposes</td>
</tr>
<tr>
<td>3</td>
<td>Every pattern should be expressed independent of the other patterns implemented</td>
</tr>
<tr>
<td>4</td>
<td>Implemented patterns should be easy to modify and delete</td>
</tr>
</tbody>
</table>

Figure 2. Implementing a pattern using the Simulation Creation Toolkit. User picks and specifies a pattern and associated if/then behaviors are added automatically

Table 2. Four design principles of the simulation creation toolkit
The first design principle relates to how the patterns included in the system are presented to the user. The second design principle deals with how the user specifies a given pattern, further defining under what conditions the pattern is executed. The third design principle is the assurance that every pattern the user implements is expressed during the program run, regardless of past or future implemented patterns. The final design principle ensures that users can always modify their program with ease.

Figure 2 depicts the three steps that occur as a user implements a pattern in the Simulation Creation Toolkit. Subsequent sections describe each of these steps.

**Patterns and “interacticons”**

The first design principle in Table 2 relates to the number of Computational Thinking Patterns available to the user and how these patterns are represented to the user. The Simulation Creation Toolkit allows users to add agent interactions by selecting from 10 different Computational Thinking Patterns, outlined in Table 1. Our research experience with more than 40 schools and 20,000 student-made projects shows that these Computational Thinking Patterns are high level patterns that are commonly implemented when creating games and simulations (Basawapatna, Koh, Repenning, Webb, & Marshall, 2011). The initial patterns included allow students to make a variety of simulations in Life Science classes including predator/prey and epidemiology. This list is by no means exhaustive and as more useful patterns are identified this palette could grow.

The first four patterns in Table 1 are “collision” patterns. These patterns occur when two agents meet in space, and include the change, absorb, transport, and push pattern. For example, the absorb pattern occurs when a Fox agent comes into contact with a Rabbit agent representing the Fox agent eating the Rabbit agent. The transport pattern and push pattern in Table 1 are collision patterns, which also happen to be “modulating” patterns. Modulating patterns change the implementation of previously modified patterns (Bjork & Holopainen, 2006). The transport and push pattern modify any movement behaviors. For example, if agent “A” were to transport agent “B” in a simulation, this transport would modify any movement rules associated with agent “A.” Specifically, on the condition that agent “B” is stacked on agent “A,” agent “A” carries agent “B” as it executes its movement rules. The subsequent four patterns in Table 1 are “movement” patterns which enable agents to move around a level. These include random movement, tracking, keyboard movement, and directional movement. The final two patterns in Table 1, generate and data count, do not belong in any category. The generate pattern allows one agent to create another agent. This can happen on a collision, for example when two Fox Agents mate creating a third Fox Agent, or once every so often such as when a Tunnel agent generates a stream of trucks in the game Frogger. Finally, the data count pattern enables the user to count populations of agents. In a predator/prey simulation, for example, it is common to plot the populations of the predator agents and the prey agents over time.

The user selects patterns to apply from an animated palette containing generic agents acting out each interaction outlined in Table 1. These animated representations of Computational Thinking Patterns are called “interacticons.” Figure 3 depicts three sequential frames of the absorb pattern interacticon.

![Figure 3](image.jpg)

In Figure 3 the generic Blue agent (left) collides with the generic Red agent (right) with the Red agent being absorbed. Interacticons provide users with a phenomenological representation of a given Computational Thinking Pattern. The user then decides which agents from their simulation to replace these generic agents with by making an analogy from the generic interacticon representation to the real world phenomena a user wishes to represent. Figure 4 shows the same three frames of Figure 3 in the case where a user chooses a Frog agent in place of the blue disk and a Butterfly agent in place of the red disk.
The Simulation Creation Toolkit enables users to make simulations by combining the 10 Computational Thinking Patterns outlined in Table 1. The user chooses a pattern via analogy with a real world phenomenon.

**Pattern specifications**

The second design principle in Table 2 requires that patterns can be customized to fit a given interaction. After the user applies a pattern, the user specifies how the pattern will work in the simulation. Specifications covers the conditions under which the pattern executes; often these include the percent chance associated with the pattern, the frequency of a pattern, and the direction it occurs in among many other possibilities. For example, if a user implements the random movement pattern, after identifying the agent involved in the pattern, the user still needs to specify how quickly the agent will move and if this movement is blocked by other agents. Figure 5 depicts how the user specifies the random movement pattern using the Simulation Creation Toolkit.

In Figure 5, the user is presented with some choices pertaining to the random movement. This includes how fast the agent moves (label 1), if it applies to all depictions of the agent (label 2), and which agents block this random movement (label 3). It should be noted that an agent can have many different depictions in AgentCubes, for example, the Ghost agent in Pacman looks different after the Pacman agent has eaten a power pellet. Different patterns have a different set of specification choices, and the choices of specifications provided to the user are tailored to how the patterns are commonly configured in our experience teaching game design and simulation activities to students.

Pattern specifications often represent system parameters. For example, the random movement specification depicted in Figure 5 enables the user to change how fast this agent movement occurs. Similarly, if a user is implementing an epidemiology simulation wherein a sick agent changes a healthy agent into a sick agent using the change pattern, the user can set a percent chance associated with this change pattern using the change specifications. In this case, the percent chance can be thought of as setting how susceptible an agent is to the infection being modeled, and this specification can be quickly changed to model different communicable illnesses.
**Backend implementation**

The Simulation Creation Toolkit automatically and immediately adds AgentCubes if/then conditionality code depending on the user selected pattern and associated specifications. The third and fourth design principle in Table 2 require that the system enables each implemented pattern to be executed regardless of prior implemented patterns and patterns should be easily modified and deleted. The backend of the Simulation Creation Toolkit employs various mechanisms to allow for this.

The AgentCubes architecture that the Simulation Creation Toolkit is built upon implies a priority based on rule order. Figure 6 is an example agent behavior with two rules residing in the agent’s “while running” method which is the only method guaranteed to be executed for a given agent each update cycle.

![Figure 6. Example agent behavior in AgentCubes](image)

The behavior of the agent depicted in Figure 6 is dictated by two rules. The first rule states that if this agent sees a Box agent to the right, then this agent will erase the agent to its right (deleting the Box agent). The second rule states that if this agent sees a Box agent to its left, it will erases itself. Behaviors are executed from top to bottom and only one rule from each method is executed every update cycle. Therefore, in the situation outlined in Figure 6, wherein this agent has a Box agent to its left and to its right, only the Box to its right will be erased and the agent will not erase itself in the current update cycle.

Programming agent behaviors at the lower if/then conditionality statement level affords users the ability to reorder rules based on their priority. At the pattern level, however, if a user implements two patterns, both should have a chance to be executed every cycle. The Simulation Creation Toolkit implements each pattern in its own method. Every update cycle, a single rule in the agent’s while-running method calls every pattern’s method enabling every pattern to be executed independent of other patterns. This ensures every pattern can be expressed during each agent update cycle.

These pattern methods also play an important role in the modification and deletion of patterns. Whenever any part of a pattern specification is modified, which can also include changing the agents present in the pattern, the method or methods that pattern resides in change immediately. The backend changes the necessary conditions and actions within the pattern method to reflect the changes to the specification. Similarly, when a user deletes a pattern, the backend deletes any method corresponding to that deleted pattern and erases any call to that method.

**Previous research**

Pattern languages have a rich history and have long been recognized as a way to capture high-level concepts and design practices in a variety of disciplines. Alexander et al. (1977) wrote *A Pattern Language*, outlining patterns one can implement to create towns, cities, and urban centers. Though related to a different discipline, the aims of *A Pattern Language* are similar to Computational Thinking Patterns in that each pattern can be thought of as a high-
level implementation concept that accommodates a given set of issues. Furthermore, patterns in *A Pattern Language* start with general implementations but are fully implemented through sub patterns. Patterns can have multiple implementations that each do something slightly different but are all in the general category of that pattern. The Simulation Creation Toolkit similarly defines general pattern categories (i.e., collision and movement), with various sub patterns and specifications that differentiate each of the pattern implementations.

More recently the value of pattern languages has also been recognized by software engineering. The seminal text *Design Patterns: Elements of Reusable Object Oriented Software* provides commonly used programming patterns to non-expert users (Gamma, Helm, Johnson & Vlissides, 1994). The book *Patterns In Game Design* applies this construct to the domain of game creation (Bjork & Holopainen, 2006). It provides a “Pattern Collection” which uses a similar categorization to the Simulation Creation Toolkit in terms of movement and collision patterns. It also outlines the idea behind “modulating patterns” described previously.

Interacticons play a vital role in the Simulation Creation Toolkit and are rooted in the field of Phenomenology. Albert Michotte, in his book *The Perception of Causality* devised multiple experiments to gain insight into how people perceive causal relationships even when none exist (Michotte, 1963). To this end, Michotte used devices such as timed image projections of one circle meeting another circle, and the second circle moving. With correct timing, Michotte noticed that people explained the motion of the second circle as due to contact with the initial circle. Michotte realized that the generic object motion implied a “functional relationship” between these objects. Many of the interactions Michotte describes mirror patterns present in the Simulation Creation Toolkit. For instance, Michotte describes the “Transporting Effect” wherein one object is perceived to transport another. With both Michotte’s experiments and Simulation Creation Toolkit interacticons, the success or failure of generic agents exhibiting a pattern depends on the ability of people to abstract out the agents of an interaction while preserving the interaction itself.

The Simulation Creation Toolkit is an attempt to domain orient end-user game design towards simulation and modeling activities through a higher-level visual language. There are many prior instances where this practice has had success. Construction Kits, for example, supply users with high-level building blocks that they can combine to solve a specific problem (Fischer & Lemke, 1988). For example, the Pinball Construction Kit provides users with pre-programmed flippers and bumper that can be placed in a level to easily prototype their own pinball game.

Generally, these problems include helping to break the complexity barrier, utility barrier (ratio of value to energy expended), automatically taking care of time consuming and technical user tasks, all while mirroring the abstractions of the application domain (Fischer & Lemke, 1988). In this respect, the aim Simulation Creation Toolkit is very similar to that of Construction Kits. Storytelling Alice provides an example of modifying an end-user programming tool with higher-level domain oriented functionality (Kelleher, 2006). Storytelling Alice, built on top of the Alice environment, provides a suite of high-level functionality that focuses users on creating narratives. Finally, Kodu, developed by Microsoft Research, provides users with the ability to create games using high level patterns but still is not fully at the interaction level as it employs the patterns as actions in a conditionality rule (Stolee & Fristoe, 2011). Kodu includes some of the same high-level patterns like tracking and transport. One big difference between Kodu and the Simulation Creation Toolkit is the absence of interacticons.

**Study design**

Two studies run on the Simulation Creation Toolkit—an in class study with 45 seventh grade Life Science students creating a predator/prey simulation, and an analogical reasoning study with six university students creating three different projects—begin to give initial insight into the system capabilities. Previous research looked at how successful sixth grade computer class students with no prior programming experience could create parts of the above predator/prey simulation (Basawapatna, Repenning, & Lewis, 2013). Unlike the current study, the previous study was not integrated into the actual class curriculum; students were not in a Life Science class. Furthermore, the previous study presented no analogical reasoning evidence and students did not have the full amount of time to complete the simulation.
7th grade in-class study

The seventh grade in-class study took place over 4 days. Most of these students had brief prior experiences programming games and simulations in AgentCubes. This study investigated to what extent the Simulation Creation Toolkit could be used efficiently and effectively to create simulations of Life Science topics currently being studied. Students programmed the predator/prey simulation in their Life Science class as they were studying ecosystems and food webs. Mentioned above, in prior experiences it was observed that the predator/prey simulation takes a week and a half to two weeks to program using AgentCubes. The predator/prey simulation consists of 16 pattern implementations, outlined in Table 3. As customary with classroom simulation studies, students were provided with scaffolding materials such as a tutorial containing a worksheet of questions that they answered as they created the simulation.

<table>
<thead>
<tr>
<th>Pattern 1 and Pattern 2</th>
<th>The Fox Agent and Rabbit Agent start out moving randomly.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pattern 3 and Pattern 4</td>
<td>The Fox and Rabbit Agent gets hungry with a given percent chance as they move.</td>
</tr>
<tr>
<td>Pattern 5 and Pattern 6</td>
<td>A hungry Fox or Rabbit dies with a given percent chance every second it does not find food…</td>
</tr>
<tr>
<td>Pattern 7 and Pattern 8</td>
<td>… and decomposes into a Grass Agent.</td>
</tr>
<tr>
<td>Pattern 9</td>
<td>A hungry Fox Agent tracks the Rabbit Agent.</td>
</tr>
<tr>
<td>Pattern 10</td>
<td>A hungry Rabbit Agent tracks the Grass Agent.</td>
</tr>
<tr>
<td>Pattern 11 and Pattern 13</td>
<td>If a hungry Fox encounters a Rabbit, it eats it and is no longer hungry.</td>
</tr>
<tr>
<td>Pattern 12 and Pattern 14</td>
<td>If a hungry Rabbit Agent encounters a grass Agent, it eats it and is no longer hungry.</td>
</tr>
<tr>
<td>Patterns 15 and 16</td>
<td>If a Fox or Rabbit is next to another Fox or Rabbit Agent respectively, it will mate with some percent chance.</td>
</tr>
</tbody>
</table>

Analogical reasoning study

The second study investigated to what extent users could analogically reason using the Simulation Creation Toolkit. Six university level students, three with prior AgentCubes experience and three without any AgentCubes experience, were given three general descriptions of requirements for programs to create. Students had as much time as they wanted to complete the program but were given no additional materials other than the descriptions and a brief five-minute introduction to the system. Table 4 provides the descriptions students received for each program – students were not provided with the “Interaction” labels in parenthesis present in Table 4, which are displayed so we can refer to each interaction later in the paper.

Table 4. Outline of patterns present in the predator/prey simulation with each interaction numbered

<table>
<thead>
<tr>
<th>Interaction</th>
<th>Outline</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interaction 1</td>
<td>Pacman moves with keyboard keys.</td>
</tr>
<tr>
<td>Interaction 2</td>
<td>All the Ghosts pursue Pacman and when they get to Pacman, Pacman disappears.</td>
</tr>
<tr>
<td>Interaction 3</td>
<td>Pacman eats pellets as he navigates around the level.</td>
</tr>
<tr>
<td>Interaction 4</td>
<td>Neither Pacman nor the Ghosts can go through the blue walls.</td>
</tr>
<tr>
<td>Description 2: Epidemiology simulation</td>
<td></td>
</tr>
<tr>
<td>Interaction 1</td>
<td>All depictions of the person move around randomly.</td>
</tr>
<tr>
<td>Interaction 2</td>
<td>A healthy person has a 30% of becoming sick each second that healthy person is next to a sick person.</td>
</tr>
<tr>
<td>Interaction 3</td>
<td>A sick person has a 30% chance of recovery every second.</td>
</tr>
<tr>
<td>Interaction 4</td>
<td>A sick person also has a 10% of death (i.e., disappearing) every second.</td>
</tr>
</tbody>
</table>

Description 3: Predator/Prey simulation

| Interaction 1 & 2 | Foxes and Rabbits move randomly. |
| Interaction 3 | Every so often the Fox Agent gets hungry;… |
| Interaction 4 | … at this point the Hungry Fox tracks the Rabbit Agent. |
| Interaction 5 & 6 | If the Hungry Fox gets to the Rabbit Agent, it kills it and is no longer hungry. |
| Interaction 7 | Eventually the dead Rabbit decomposes. |
Interaction 8  Hungry Foxes can also sometimes die of Hunger.
Interaction 9  Finally, Foxes sometimes reproduce with other Foxes creating a new Fox at some percentage;
Interaction 10  ... Rabbits sometimes mate with other Rabbits creating a new Rabbit at some percentage.

Results and discussion

Seventh grade in-class study results and discussion

Figure 7 depicts a sixteen axes graph with the value at each axis representing the average percent pattern correctness among all students for that particular pattern. Patterns were scored as follows: 2 points were given if the pattern and agent were correct and 1 point was given for each specification that was correct. If every student completed the simulation entirely correct, Figure 7 would be 16-sided shape with every vertex at 100%. The lowest pattern in Figure 7 is 85% correct on Pattern 14 meaning that students, for the most part, were able to correctly implement the patterns and specifications necessary for the predator/prey simulation using the Simulation Creation Toolkit.

![Figure 7. Average percent pattern correctness for each pattern in the predator/prey simulation among all seventh grade students](image)

Table 5 shows the percent of students who had correct simulations, simulations with one mistake, two mistakes, and three or more mistakes. A mistake is defined as a required interaction that was not implemented or was implemented incorrectly (the pattern or a specification was incorrect or missing).
Table 5. Percent of 7th grade students with correct predator/prey simulations

<table>
<thead>
<tr>
<th>Number of students</th>
<th>Perfect simulation</th>
<th>1 incorrect pattern</th>
<th>2 incorrect patterns</th>
<th>3 or more incorrect patterns</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>18</td>
<td>9</td>
<td>9</td>
<td>9</td>
</tr>
<tr>
<td>% of students</td>
<td>40%</td>
<td>20%</td>
<td>20%</td>
<td>20%</td>
</tr>
</tbody>
</table>

Table 5 shows that 40% of seventh grade students were able to create a perfect predator/prey simulation in four days. Furthermore, 80% of students had two incorrect patterns or less. The above data is promising in terms of using a higher-level pattern based language to integrate simulation creation activities in the classroom. Figure 7 shows that students were able to construct the specific interactions necessary to create the simulation. In Table 5 we see that most of these students, who had no prior experience with the Simulation Creation Toolkit, were able to create working or almost working simulations in substantially less time.

**Analogical reasoning study results and discussion**

The analogical reasoning study looked at the extent to which users could create games and simulations given a general description of interactions (Table 4 shows which parts of the description correspond to each program interaction). Each interaction was inspected manually to see to what extent the interaction was correct. Interactions were given a “√” if they were entirely correct, a “√-“ if the pattern(s) were correct but a specification was incorrect, and “X” if the pattern(s) were incorrect. Table 6 depicts the results for the Pacman program.

Table 6. Pacman simulation analogical reasoning study results

<table>
<thead>
<tr>
<th>Participant</th>
<th>Duration</th>
<th>Inter. 1</th>
<th>Inter. 2</th>
<th>Inter. 3</th>
<th>Inter. 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>1*</td>
<td>13 minutes</td>
<td>√</td>
<td>√</td>
<td>√</td>
<td>√</td>
</tr>
<tr>
<td>2*</td>
<td>19 minutes</td>
<td>√</td>
<td>√</td>
<td>√</td>
<td>√</td>
</tr>
<tr>
<td>4*</td>
<td>14 minutes</td>
<td>√</td>
<td>√</td>
<td>√</td>
<td>√</td>
</tr>
<tr>
<td>3**</td>
<td>20 minutes</td>
<td>√</td>
<td>√</td>
<td>√</td>
<td>√</td>
</tr>
<tr>
<td>5**</td>
<td>36 minutes</td>
<td>√</td>
<td>√</td>
<td>√</td>
<td>√</td>
</tr>
<tr>
<td>6**</td>
<td>30 minutes</td>
<td>√</td>
<td>√</td>
<td>√</td>
<td>√</td>
</tr>
</tbody>
</table>

Note. *Users with prior AgentCubes experience; **Users with no AgentCubes experience.

All participants created the Pacman simulation entirely correctly using the Simulation Creation Toolkit. The users with no prior AgentCubes experience seemed to take longer to create their simulations. It should be noted that in our experience students with prior AgentCubes experience can take 2 hours to program Pacman. Table 7 depicts the results for the Epidemiology simulation.

Table 7. Epidemiology simulation analogical reasoning study results

<table>
<thead>
<tr>
<th>Participant</th>
<th>Duration</th>
<th>Inter. 1</th>
<th>Inter. 2</th>
<th>Inter. 3</th>
<th>Inter. 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>1*</td>
<td>15 minutes</td>
<td>√</td>
<td>√-</td>
<td>√-</td>
<td>√-</td>
</tr>
<tr>
<td>2*</td>
<td>9 minutes</td>
<td>√</td>
<td>√-</td>
<td>√</td>
<td>√</td>
</tr>
<tr>
<td>4*</td>
<td>18 minutes</td>
<td>√</td>
<td>√</td>
<td>√</td>
<td>√</td>
</tr>
<tr>
<td>3**</td>
<td>13 minutes</td>
<td>√</td>
<td>√</td>
<td>√</td>
<td>√</td>
</tr>
<tr>
<td>5**</td>
<td>40 minutes</td>
<td>√</td>
<td>√-</td>
<td>√-</td>
<td>√</td>
</tr>
<tr>
<td>6**</td>
<td>44 minutes</td>
<td>√</td>
<td>√</td>
<td>√</td>
<td>√</td>
</tr>
</tbody>
</table>

Note. *Users with prior AgentCubes experience; **Users with no AgentCubes experience.

The Epidemiology Simulation study shows that users had trouble with some pattern specifications. Still, most users identified the correct patterns. Interactions only depict the general pattern; thus, users could make the correct analogy and pick the correct interaction but still overlook a specification choice. Three users completed the simulation entirely correctly; two of them were novice users. The sample size is too small to draw any conclusions about novice users versus user who have had prior AgentCubes experience; however, the results in general are promising in terms of analogical reasoning with interactions. This data also points to the possible need for depicting the specifications in a way that is more intuitive for the users. Table 8 depicts the results for the predator/prey simulation analogical reasoning study.
The results in Table 8 show that users struggled with the more complicated predator/prey simulation. Certain interactions were incorrect; the biggest one was interaction 5 and 6 wherein the hungry Fox and hungry Rabbit agent change back into a regular Fox and Rabbit agent after eating. Many users stated that the interaction for the change pattern was somewhat misleading. Namely, the interaction involves having a dead agent change a hungry agent back into a normal agent which was unintuitive. This points to the possible need for a variety of interaction examples showing multiple different applications for each pattern rather than one generic interaction.

**General discussion**

The above results indicate that novice students can use the mechanics of the Simulation Creation Toolkit effectively and in a time-efficient manner to make simulations in-class. Furthermore, the small scale analogical reasoning study gives hope to the idea of users programming simulations directly by analogy with very little scaffolding provided. In the broader educational context, this tool might be a step towards more pragmatic constructivist activities involving computational thinking in the classroom environment (Karagiorgi & Symeou, 2005).

Previous research on the Consume-Create spectrum related to classroom simulation activities provides a framework with which we can begin to analyze the efficacy the Simulation Creation Toolkit approach (Basawapatna, Repenning, Koh, & Savignano, 2014). The Consume-Create spectrum aims to enumerate simulation related activities that teachers can do in the classroom environment. Activities on the Consume end of the spectrum, such as giving students an animation or an interactive simulation, are convenient for the classroom environment as they take very little class time, however, have minimal value in terms of exposing students to computational thinking concepts. On the Create end of the spectrum, we have activities such as traditional programming and end-user programming. For example, having students iteratively create and experiment on a simulation using an end-user programming environment exposes students to computational thinking concepts, but as previously mentioned, might be impractical because of class time constraints.

The Simulation Creation Toolkit is adjacent to Construction Set Simulation/Construction Kit activities, which are slightly more on the Consumption side of the spectrum, wherein students do not program elements, but rather, place the elements in unique configurations to experiment on a given problem. For example, one can think of placing pre-programmed resistors or capacitors to make unique circuits in a circuit construction kit. Previous research shows that such strategies can have potentially huge effects in relatively small intervention times (1-2 hours) in terms of increasing deep student knowledge of an issue (Wieman, Adams, & Perkins, 2008). However, the extent to which students are thinking computationally as they do this activity is debatable (Basawapatna, Repenning, Koh & Savignano, 2014). Similarly, on the Creation side of the spectrum, the Simulation Creation Toolkit is adjacent to end-user programming tools which, as mentioned above, are effective in integrating computational thinking concepts (Repenning, Webb, & Ioannidou, 2010).
The initial Simulation Creation Toolkit results presented here indicate that the pattern programming strategy employed begins to balance student simulation construction that enables computational thinking while also preserving convenience in the classroom environment. Students, with no prior exposure to the Simulation Creation Toolkit, were able to create simulations in the classroom environment and displayed an ability to create simulations through analogy using the system. Therefore, the data indicates that the general strategy of exploiting phenomenology at the pattern level provides a viable point on the Consume-Create spectrum for further in-class exploration and may eventually be a sweet spot for teachers in terms of exposing students to computational thinking within the time and curricular constraints of their classroom.

Comparing the Simulation Creation Toolkit with another related pattern programming approach in game and simulation design illuminate the differences and contextualize these results. For example, Microsoft Kodu allows users to build games by providing some of the same high-level patterns like tracking (Stoee & Fristoe, 2011). However, the approach taken by the Simulation Creation Toolkit involves interacticons which employs the human ability to make analogies with these generic phenomenological interactions and the real world. This abstraction is a key component of computational thinking. Kodu, on the other hand, provides static icons and explanations with descriptions that guide users to select the correct pattern. Kodu also makes users program at the behavior level by making these higher-level patterns, like tracking, actions in the behavior rules. Therefore, it is up to the user to implement the pattern rules in the correct order and with the necessary associated conditions. Using the Simulation Creation Toolkit, users program purely at the pattern level—this allows for easier and quicker user implementations but at the cost of not having the freedom of pattern specifications available to users of Kodu. This presents an interesting tradeoff and future research will look at how increasing the palette of patterns and specifications in the Simulation Creation Toolkit expands user creation freedom at the cost of increasing complexity of use.

The results also begin to expose shortcomings of the Simulation Creation Toolkit that can be improved upon. For one, the analogical reasoning and in-class study seem to show that users can pick the correct patterns, but do not necessarily choose the correct pattern specifications. Developing a way to extend the power of analogical reasoning and interacticons to the specifications might be a way to alleviate this. One idea could be to have a test world where the agents not only enact the pattern but change to reflect the specifications of the pattern in real time. For example, if a student specifies that the chaser agent should move more quickly in the tracking pattern, then in the test world the student would see the chaser agent begin to move faster as it tracks the other agent. From this the user might be better able to visualize the consequence of their thinking and possibly modify the pattern specification accordingly.

Further studies should be completed to draw more concrete conclusions about how the level of abstraction corresponds to computational thinking. A study that enables students to program many in-class simulations over the course of the semester would enable the elimination of scaffolding. In this case, would students still be able to quickly model different phenomena using the Simulation Creation Toolkit? Furthermore, such a study would see if the initial analogical reasoning benefits uncovered in this study transfer to the classroom environment over the course of the semester.

**Conclusion**

This paper presents a new pattern-based tool, entitled the Simulation Creation Toolkit, which enables users to create simulations at a higher level by analogy through employing interactions rooted in phenomenology. Initial results are promising. Furthermore, this study is a data point towards increasing end-user programming tool effectiveness in computational thinking classroom integration. This research could one day enable universal adoption of computational thinking concepts inside the classroom environment.

**Acknowledgments**

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References


An e-Learning Theoretical Framework

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ABSTRACT

E-learning systems have witnessed a usage and research increase in the past decade. This article presents the e-learning concepts ecosystem. It summarizes the various scopes on e-learning studies. Here we propose an e-learning theoretical framework. This theory framework is based upon three principal dimensions: users, technology, and services related to e-learning. This article presents an in-depth literature review on those dimensions. The article first presents the related concepts of computer use in learning across time, revealing the emergence of new trends on e-learning. The theoretical framework is a contribution for guiding e-learning studies. The article classifies the stakeholder groups and their relationship with e-learning systems. The framework shows a typology of e-learning systems’ services. This theoretical approach integrates learning strategies, technologies and stakeholders.

Keywords


Introduction

E-learning unites two main areas, learning and technology. Learning is a cognitive process for achieving knowledge, and technology is an enabler of the learning process, meaning that technology is used like any other tool in the education praxis, as is a pencil or a notebook, for example. Although this seems quite simplistic and logical, a pencil is more technologically transparent tool, and its use may therefore seem more natural to many. Furthermore, technology underpins other problematic situations because it includes various dimensions. E-learning systems aggregate various tools, such as writing technologies, communication technologies, visualization, and storage. For these reasons, researchers and scientists have sought to transform e-learning systems into technically transparent tool, like a pencil or notebook. The e-learning literature is vast and continues to grow steadily (Aparicio, Bacao, & Oliveira, 2014b). Investigating e-learning systems’ adoption and usage reveals that continuous growth everywhere in the world, as well (OECD, 2012). The growth rate of on-line courses stands at 65% (Means, Toyama, Murphy, Bakia, & Jones, 2009), and some researchers suggest that at a governmental level, policies should be advocated enabling the e-learning usage (Kong et al., 2014).

As Hart (2009, p. 28) says “reviewing the work of others you will be able to identify the methodological assumptions and the research strategies.” For these reasons, a holistic literature review is a valuable guide for researchers. However, no such overall view exists in the current literature. Consequently, the contribution of this article is threefold. First, we identify e-learning concepts ecosystem. Second, e-learning is examined from different angles; some studies are focused on how platforms operate to deliver information; others focus on the classes’ pedagogical content development, others focus on the user interaction. This article presents a broad literature review. Finally, based on the literature review we present a theoretical framework on e-learning systems.

The paper is structured in six sections: the first presents a discussion of the e-learning concept; the second presents a literature review on e-learning related concepts; the third presents the trends of the concepts, based on a bibliometric study; the fourth summarizes various e-learning studies. Several dimensions of e-learning systems, such as stakeholders, pedagogical models, instructional strategies and learning technologies, make up the fifth section. In the last section, we present the main result of this literature review, a theoretical framework for e-learning.
E-Learning systems related concepts

E-Learning systems are an evolving concept, rooted in the concept of Computer-Assisted Instruction (CAI) (Zinn, 2000). The concept of CAI first appeared in 1955 as a means of teaching problem-solving (Zinn, 2000). Table 1 presents concepts related to e-learning. Computer assisted learning definitions have been studied in various ways. Some studies stress the technology while others have focused on communication (Mason & Rennie, 2006), as shown in Table 2. Our research reveals 23 concepts that belong to the use of computers in learning activities, used especially for learning purposes. The following table is arranged in ascending order according to the number of appearances of concepts in scholarly publications from 1960 to 2014.

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
<th>Concept Focus</th>
<th>Authors</th>
</tr>
</thead>
<tbody>
<tr>
<td>CBE</td>
<td>Computer-Based Education</td>
<td>Concept that focuses on the variety of computer uses in education.</td>
<td>(Barson, Levine, Smith, Scholl, &amp; Scholl, 1963) (Zinn, 2000)</td>
</tr>
<tr>
<td>LMS</td>
<td>Learning Management Systems</td>
<td>Supports registering services, tracks and delivering content to learners. It also reports learner progress and assessing results. LMS focuses on contents and teacher/student interaction.</td>
<td>(Becker, 1968) (Ismail, 2001) (Lee &amp; Lee, 2008)</td>
</tr>
<tr>
<td>CMI</td>
<td>Computer-Managed Instruction</td>
<td>CMI stresses the teacher’s tasks.</td>
<td>(Molnar &amp; Sherman, 1969) (Zinn, 2000)</td>
</tr>
<tr>
<td>CAE</td>
<td>Computer-Assisted Education</td>
<td>CAE concept refers to the use of computer for materials’ production and focuses on the students’ use of the computer in learning.</td>
<td>(Bitzer &amp; Others, 1970) (Zinn, 2000)</td>
</tr>
<tr>
<td>ALE</td>
<td>Artificial Learning Environments</td>
<td>Artifacts’ usage as a mediator in learning within a specific environment.</td>
<td>(Fiol &amp; Lyles, 1985)</td>
</tr>
<tr>
<td>m-Learning</td>
<td>Mobile Learning</td>
<td>The first way to fight illiteracy. Pessanelli (1993) gives a futuristic approach to how learning could be in the 21st century, focusing the concept as modular plug-in school. Drumm &amp; Groom used the concept to conceptualize a cyber mobile library. m-Learning is the focus of flexibilization in the learning class environment and the use of various learning sources.</td>
<td>(Darazsdi &amp; May, 1989) (Pessanelli, 1993) (Drumm &amp; Groom, 1997) (Rushby, 1998)</td>
</tr>
<tr>
<td>SRE</td>
<td>Self-Regulatory Efficacy</td>
<td>Concept focused on learner’s independent assessment of self-regulatory learning ability.</td>
<td>(Bandura, 1994) (Joo, Bong, &amp; Choi, 2000)</td>
</tr>
<tr>
<td>CSCL</td>
<td>Computer Support for</td>
<td>Concept that focuses on computers as a way to facilitate, augment, and redefine support</td>
<td>(Koschmann, 1994) (Sthal, Koschmann, &amp; Suthers, 1994)</td>
</tr>
<tr>
<td>Concept</td>
<td>Definition</td>
<td>References</td>
<td></td>
</tr>
<tr>
<td>---------</td>
<td>------------</td>
<td>------------</td>
<td></td>
</tr>
<tr>
<td>REAL</td>
<td>Rich Environments for Active Learning</td>
<td>(Ludvigsen &amp; Morch, 2010) (Morch, 2013)</td>
<td></td>
</tr>
<tr>
<td>Mega-University CFL</td>
<td>Concept that combines distance learning, higher education, size and use of technology.</td>
<td>(Daniel, 1996)</td>
<td></td>
</tr>
<tr>
<td>LCMS</td>
<td>Learning Content Management Systems</td>
<td>(Ismail, 2001)</td>
<td></td>
</tr>
<tr>
<td>B-Learning</td>
<td>Blended Learning</td>
<td>(Singh, 2003)</td>
<td></td>
</tr>
<tr>
<td>ILM</td>
<td>Internet-based Learning Medium</td>
<td>(Lee et al., 2005)</td>
<td></td>
</tr>
<tr>
<td>LOOC</td>
<td>Little Open Online Course,</td>
<td>Focus on the directed instructions from the teacher to the students.</td>
<td>(Kolowich, 2012)</td>
</tr>
<tr>
<td>SPOC</td>
<td>Small Private Online Course</td>
<td>MOOC usage as a supplement to classroom learning, not as a substitute to the traditional way of teaching.</td>
<td>(Fox, 2013)</td>
</tr>
</tbody>
</table>

From Table 1 we see that e-learning concept was not the first term to be used in conceptualizing the use of computerized systems to enable or facilitate the learning process. In the 1960s, this concept focused on task accomplishment and thereafter focused more on the students. Mary Alice White coined the term “e-learning” in
1983, in a journal article entitled “Synthesis of Research on Electronic Learning.” E-learning was defined as “learning via electronic sources, such as television, computer, videodisk, teletext, videotext.” (White, 1983, p. 13). In 1997, e-learning meant an abbreviation of electronic learning, in turn meaning “an interactive distance learning” environment (Morri, 1997). Despite the use of the e-learning term, another author referred to the capacity of technologies combined with distance learning and with universities, which was named “mega-university” (Daniel, 1996). Online learning is another concept related to e-learning. Online learning can be defined as learning that takes place partially or entirely over the internet making information or knowledge available to users disregarding time restrictions or geographic proximity (Sun, Tsai, Finger, Chen, & Yeh, 2008). E-learning systems’ concepts include a technological and a functional focus, regarding the Internet possibilities in overcoming time and space issues. Figure 1 shows a timeline of the main e-learning concepts. Concepts are shown according to the first publication date.

**E-Learning concept trends**

Today the e-learning concept, apart from technology, includes learning strategies, learning methods, and lately is very much directed to the vast possibilities of content diffusion and connection. The concept trend no longer means simply the use of a computer as an artifact in the learning process. Figure 2 illustrates the evolution and frequency of each concept, according to searches made with the Google Scholar search engine. Each search was performed at five-year intervals, from 1960 to 2014, for each exact term, using double quotation operator (Figure 2). The chart gives a clear visualization of the evolution and trends since 1960 of the most used concepts, in terms of publication in scholarly conference papers and journal articles. In order to visualize these variables we construct a circle using an information aesthetic software (Krzywinski et al., 2009). The figure can be read as follows: if we divide the circle into semicircles we have the left hand part, with the concepts and the related publications per each concept and the right hand part with the time intervals (from 1960 to 2014). To connect these two sides of the circle we have colored ribbons, which relate each concept publication amount with the correspondent time interval. From this figure we gain the overall picture of the publication history on e-learning related concepts over time. The colored ribbons have different widths – wider indicating a greater number of publications in each concept per each time period.

Figure 2 was constructed with the bibliometric study of the publications, indexed in Google Scholar, for the most frequent e-learning-related concepts (on the left-hand side of the semicircle): CAI, CAL, SDL, e-learning, LMS, CSCL, among others (Aparicio et al., 2014b). CAI concept is the most used, because it appeared first and is still widely used today. From Figure 2 we can also see that CAI is the most mentioned concept; we can see the yellow relationship between the concept and all time intervals. CAI ribbons (yellow colored) are balanced across time, except in the 1960s and ’70s, when the concept was introduced. The other four concepts, SDL (red ribbon), CAL (pink ribbon), e-learning (blue ribbon), and LMS (orange ribbon), are of equal importance, although some of them appeared later. SDL, in red, is predominantly connected from 2005 until 2014 (Y05-09 and Y10-14). The most important CAL connections were formed from 2000 to 2014, even though the concept was used earlier. The e-learning concept, in blue, is mainly connected from 2000 until 2014. Other concepts show a relationship with the time intervals but these connections are not as strong as the others. Regarding the right-hand semicircle, it clearly

![Figure 1. Timeline of E-learning related concepts (Aparicio, Bacao, & Oliveira, 2014b)](image-url)
shows that the earliest years, from 1960 to 1999, account for only one-third of the publications, with approximately two-thirds of all publications produced thereafter. This leads to the idea that the computers’ presence in the learning process has been explored and studied more in the last 14 years than it had been in the previous 40.

Figure 2. E-learning concepts related to the time reference

The most often returned terms were: CAI, CAL, computer-based education (CBE), e-learning, learning management systems (LMS), self-directed learning (SDL), and massive open online courses (MOOC). All these concepts have two aspects in common: learning and computers; except the SDL concept, which derives from psychology (Bandura, 1994) and does not necessarily apply to computer usage. We found three concepts: small private online course (SPOC); little open online course (LOOC), and distributed open collaborative courses (DOCC). These concepts are yet to be studied in scientific research, and stand in contrast to MOOCs. SPOC focuses on a private audience, and is defined as a supplementary way of learning apart from regular face-to-face classes. LOOC differentiates itself from MOOC as it is based on a different pedagogical model; it provides direct instructions to students. DOCC also differentiates from MOOC in its focus on the pedagogic engagement of all actors, underlining on one hand the invisible work of teachers, and on the other the collective intelligence of scholars. The graphic that illustrates the evolution concept indicates a tendency from the individual learning to a global learning. Nowadays, e-learning can also mean massive distribution of content and global classes for all the Internet users.

E-Learning studies

E-learning studies focus on several areas. Table 2 summarizes various examples of e-learning according to three main groups, people, technology, and services. As Leidner & Jarvenpaa (1995) say, IT impact on learning does not
solve all problems, we have to take into account people and models of learning. Some studies seek to understand the adoption of e-learning systems; others assess the success of course contents; others evaluate the perceived student satisfaction of specific e-learning course environments.

<table>
<thead>
<tr>
<th>e-Learning studies</th>
<th>People</th>
<th>Technology</th>
<th>Services</th>
<th>Authors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Studies on course contents and activities</td>
<td></td>
<td>√</td>
<td>√</td>
<td>(Brox, Painho, Bação, &amp; Kuhn, 2004; Piccoli et al., 2001; Rosenberg, 2005; Zinn, 2000)</td>
</tr>
<tr>
<td>Studies on augmented reality in e-learning</td>
<td></td>
<td>√</td>
<td></td>
<td>(Bacca, Baldiris, Fabregat, Graf, &amp; Kinshuk, 2014; Lee, Choi, &amp; Park, 2009)</td>
</tr>
<tr>
<td>Studies about students’ interaction in collaborative learning environments</td>
<td>√</td>
<td></td>
<td>√</td>
<td>(Bain et al., 1998; Ludvigsen &amp; Morch, 2010)</td>
</tr>
<tr>
<td>Study on cultural differences in learning</td>
<td></td>
<td>√</td>
<td>√</td>
<td>(McLoughlin &amp; Oliver, 1999; Yang, Kinshuk, Yu, Chen, &amp; Huang, 2014)</td>
</tr>
<tr>
<td>Study on the Internet-based learning medium in a motivational perspective</td>
<td>√</td>
<td></td>
<td></td>
<td>(D. Lee, Chung, &amp; Kim, 2013; J. Lee, Bharosa, Yang, Janssen, &amp; Rao, 2011)</td>
</tr>
<tr>
<td>Studies on e-learning systems adoption</td>
<td></td>
<td>√</td>
<td>√</td>
<td>(Chen &amp; Liu, 2013; J. Lee et al., 2011)</td>
</tr>
<tr>
<td>Studies on the satisfaction level of e-learning systems usage.</td>
<td>√</td>
<td></td>
<td>√</td>
<td>(Aggelidis &amp; Chatzoglou, 2012; Sun, Tsai, Finger, Chen, &amp; Yeh, 2008)</td>
</tr>
<tr>
<td>Studies on e-learning and digital divide</td>
<td></td>
<td>√</td>
<td>√</td>
<td>(Chen &amp; Liu, 2013; Cruz-Jesus, Oliveira, &amp; Bacoa, 2012)</td>
</tr>
<tr>
<td>Studies about trust level, satisfaction, and adoption of e-learning.</td>
<td>√</td>
<td></td>
<td>√</td>
<td>(Kassim et al., 2012; Thoms, Garrett, Herrera, &amp; Ryan, 2008)</td>
</tr>
<tr>
<td>Studies on e-learning evaluation processes</td>
<td></td>
<td>√</td>
<td></td>
<td>(Oliver &amp; Herrington, 2003; Vavpotič, Žvanut, &amp; Trobec, 2013)</td>
</tr>
<tr>
<td>Studies on MOOCs’ business models</td>
<td></td>
<td>√</td>
<td></td>
<td>(Aparicio, Bacoa, &amp; Oliveira, 2014a; Belleflamme &amp; Jacqmin, 2014; Dellarocas &amp; Van Alstyne, 2013)</td>
</tr>
</tbody>
</table>

From Table 2 we see that even if the study addresses students’ adoption or satisfaction, the contents, or even the way courses are designed and distributed, we can group those studies and find overlaps among them. This leads to the idea that when studying e-learning, researchers have to include variables other than technology. According to the studies examined, the way contents are delivered and the underlying learning strategies also play important roles in e-learning studies.

Apart from these dimensions, recent disruptive conditions have brought a massive diffusion of online learning through various formats, from closed to open learning, and the massification of open online courses (MOOCs) has been verified. McAuley et al. (2010, p. 4) define massive online open courses as “An online phenomenon gathering momentum over the past few years; an MOOC integrates the connectivity of social networking, the facilitation of an acknowledged expert in the field of study, and a collection of freely accessible online resources.” Allison et al. (2012) stated that MOOCs are disrupting the learning environment due to the global free adoption and use of these open courses. Although according to a study done by Jordan (2013), students or simply public users are enrolling in different courses by the thousands, for example, one of the largest (measured by the number of enrolled students) has 180,000 and one of the smallest has 20,000. These figures demonstrate a massive quantity of students enrolled, comparing to a face-to-face university course that never reaches such numbers of students; nor does a teacher reach such a high number of students in her/his entire career.

From the above-mentioned studies one could believe that adoption is no longer a problem in e-learning, but a study by Jordan (2013) of the disruptive potential of MOOCs compares the enrolment rates with the completion rates per
each course and for all of them, finding that completion rates are very low. Motivation studies can also enlighten us with the disruptive potential of MOOCs, such as, “the individuals the MOOC revolution is supposed to help the most – those without access to higher education in developing countries – are conspicuously underrepresented among the early adopters” (Christensen et al., 2013, p. 8). MOOCs allow for a massive distribution of expressed knowledge, especially for those who cannot reach universities courses, due to economic, geographic, or political reasons. As a matter of fact, according to an empirical study (Christensen et al., 2013) MOOC attracts mainly young, well-educated and employed people from developed countries.

This summary of e-learning studies maps the various areas when studying e-learning and exposes the idea that e-learning should be studied using a combination of various dimensions.

E-learning systems dimensions

Information systems are composed of various dimensions. From a conceptual point of view the system is an artifact (Beckman, 2002), and this author considers the use of computers in education an “artificialization.” Artifacts are not only technology, but also and mostly “a complex and changing combination of people and technology” (Dahlbom, 1996, p. 43). Technology implements artifacts and information technology serves human purposes, providing support to several tasks (March & Smith, 1995). Within this context, we present in this section the e-learning systems dimensions, in order to prepare our e-learning theory framework.

E-learning systems stakeholders

Stakeholder analysis entails the identification of internal and external groups or individuals that can directly and indirectly affect an organization (Freeman, 2010; Stoner, Freeman, & Gilbert, 1995). Stakeholder theory can be applied to other fields beyond management (Phillips, Freeman, & Wicks, 2003). Stakeholders analysis has been used in information studies to identify the systems’ users and their direct or indirect interaction (Papazafeiropoulou, Pouloudi, & Currie, 2001; Wagner, Hassanein, & Head, 2008). We summarize the stakeholders of e-learning systems in Table 3.

<table>
<thead>
<tr>
<th>Stakeholders</th>
<th>Group</th>
<th>Direct Action</th>
<th>Internal</th>
<th>External</th>
</tr>
</thead>
<tbody>
<tr>
<td>Students</td>
<td>Customers</td>
<td>✓</td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Employers</td>
<td>Customers</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Educational Institutions</td>
<td>Suppliers</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Accreditation Bodies</td>
<td>Suppliers</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Teachers</td>
<td>Suppliers</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Content Providers</td>
<td>Suppliers</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Education Ministry</td>
<td>Board and Shareholders</td>
<td>✓</td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Teachers’ Association</td>
<td>Professional Associations</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Students’ Commissions</td>
<td>Special Interest Groups</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Technology Providers</td>
<td>Suppliers</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Customers are the ultimate users of the system for learning since e-learning systems are an important communication channel between learners and instructors. Learners can be individual students or company employees who are using these systems according to the development policies of their employees. In their case they are external users but they interact directly with the system. Suppliers can be schools, universities, or educational institutions in general; this stakeholder group is an internal group of users who interact directly with the system. Accreditation bodies are external; they interact directly with the system for auditing purposes. Teachers are part of the supplier group; they are internal users and interact directly with the e-learning platforms. Content providers can be internal or external users but they interact directly with the system. Other external stakeholders that interact directly with the e-learning systems are: education ministry, teachers’ associations, students’ commissions and technology providers. Education ministry is considered as a board and shareholder because public institutions are funded by this ministry. They have a
direct interaction with the systems in order to accompany the instructional institutions in their teaching role. Teachers and student groups can also interact directly with the system if they promote learning or research activities. Although technology providers are external to the system, they can provide maintenance services to the technological part of the system by giving technical support. Each stakeholders group interacts differently with the system, although all of the stakeholders play an important role within the e-learning system activities.

Elements of an e-learning system

E-Learning theory comprises three elements. According to Dabbagh (2005) e-learning can be defined through a theory-based framework that relates learning technologies, instructional strategies, and pedagogical models or constructs. Dabbagh’s framework (2005) includes multiple dimensions, such as the way people learn (open/flexible way), with the learning strategy (collaboration, exploration, problem-solving) and also with technology. It is a pedagogical model, and “cognitive models or theoretical constructs [are] derived from knowledge acquisition models or views about cognition and knowledge, which form the basis for learning theory. In other words, they are the mechanism by which we link theory to practice” (Mehlenbacher, 2010, p. 146). Instructional strategies facilitate learning, such as, collaboration, articulation, reflection, and role-playing among others. Although they are pedagogical models, our main objective in this study is to review the literature on e-learning systems. Subsequent to Table 1, which presents the concepts of the context of the e-learning systems, we constructed Table 4 in which those concepts are classified according to two ways of e-learning definitional dimensions. First, the concepts are classified according to Dabbagh’s (2005) framework, according to whether the concepts reflect a pedagogical model, instructional strategy, or a learning technology. Second, we also identify the concepts according to Mason & Rennie’s (2006) classification of e-learning perspectives, whether concepts are content driven, communication focused, or technologically oriented.

Table 4. e-Learning concept perspectives overlapping

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Pedagogical models</td>
<td>Instructional strategies</td>
</tr>
<tr>
<td>1960</td>
<td>CAI</td>
<td>✓</td>
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Pedagogical models, instructional strategies, and learning technologies, combined together, form a framework applicable to e-learning (Dabbagh, 2005). These three components enable the linkage between who (open learning, distributed learning, or communities of practice, among others) is participating in the learning process, with the way in which these features interact (collaborating, articulation, reflecting, exploring) and the technologies through which the communication occurs (synchronous, asynchronous, communication tools, course management tools, among others).

**Pedagogical models in e-learning**

Pedagogical models are the basis of learning theory, as they derive from knowledge acquisition. From a pedagogical point of view these models are mechanisms that link e-learning theory to e-learning practice (Dabbagh, 2005). The pedagogical models in e-learning are open learning, distributed learning, learning communities, communities of practice, and knowledge building communities. The open learning can take several forms, for example, it can be a workshop, a seminar, a night course, or a distance course. Some examples on the Web are: “knowledge networks, knowledge portals, asynchronous learning networks, virtual classrooms, and telelearning” (Dabbagh, 2005, p. 30). Distributed learning is focused on the learning distribution resulting in a combined channels situation that allows learners to access education through technology or not in a way that can be obtained synchronously or asynchronously anywhere (Dabbagh, 2005). In many situations learning communities are composed of students in universities who “tend to feel more self-confident and to feel supported by peers, by instructors, and by the college” (Patterson, 2011, p. 20). Communities of practice (CoP) are defined by Wenger (1999) as informal groups of people who share the same interests on a subject. Communities of practice share interests and best practices and collaborate not only in academia but also in industry. These communities usually have regularly scheduled meetings, CoP meet face-to-face or in virtual environments (Liu, Chen, Sun, Wible, & Kuo, 2010; Wenger, 1999). A knowledge building community is perceived as a group having “commitment among its members to invest their resources in the collective, upgrading of knowledge” (Hewitt & Scardamalia, 1998, p. 82). These communities pursue the creation of knowledge by sharing individual knowledge in order to achieve learning. The pedagogical models applied to e-learning are supported in the following attributes: learning is a social process, learning in group is fundamental to achieve knowledge; distance is unimportant (space questions are blurred); teaching and learning can be segregated in time and space.

**Instructional strategies**

Instructional strategies operationalize the pedagogical models, since strategies consist of general approaches to a learning model, which is to say, the instructional. Jonassen et al. (1997) present five instructional strategies that, in fact, are plans and techniques that the instructor uses in order to engage the learners – in other words; instructional strategies are enablers to learning. The authors state that instructional strategies differ from learning strategies, as learning strategies are mental tools that students use to understand and learn more (Jonassen et al., 1997). The authors state that each instructional condition should meet a different instructional strategy.

**Learning technologies**

Many authors have defined the characteristics of the learning technologies to support a learning environment of collaboration and supported learning, and have left room for various perspectives (Dabbagh, 2005; Hsieh & Cho, 2011; McLoughlin & Oliver, 1999; Oliver & Herrington, 2003; Rourke & Anderson, 2002). A constructivist epistemological point of view (Hannafin, Hannafin, Land, & Oliver, 1997) requires integrated strategies, aligning several foundations and environments: psychological, pedagogical, cultural, pragmatic, and technological, since according to the characteristics of this vision “knowledge depends on the knower’s frame of reference” (Dabbagh, 2005, p. 29). Oliver and Herrington (2003) construct an e-learning framework composed of technological elements grouped into three main areas in learning: resources, supports, and activities. Table 5 summarizes these instructional strategies and the correspondent technologies’ functionalities.
### Table 5. Instructional strategies and learning technologies

<table>
<thead>
<tr>
<th>Strategies</th>
<th>Authentic activities</th>
<th>Problem solving</th>
<th>Role playing</th>
<th>Articulation &amp; reflection</th>
<th>Collaboration &amp; negotiation</th>
<th>Multi-perspectives</th>
<th>Modeling &amp; explaining</th>
<th>Scaffolding</th>
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<td>One-on-one mentoring</td>
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### E-learning theory framework

A framework “classifies the important factors in information systems development can imply that these factors are causally connected with successful systems development” (Gregor, Martin, Fernandez, Stern, & Vitale, 2006, p. 619). In this framework (Figure 3), we present the main information systems dimensions adapted to e-learning systems. This framework is a theoretical generalization (Carroll & Swatman, 2000; Lee & Baskerville, 2003) resulting from the literature review on e-learning dimensions.

The e-learning systems' theoretical framework contains the three main components of information systems. These components are people, technologies, and services. People interact with e-learning systems. E-learning technologies enable the direct or indirect interaction of the different groups of users. Technologies provide support to integrate content, enable communication, and provide collaboration tools. E-learning services integrate all the activities corresponding to pedagogical models and to instructional strategies. The complex interaction combination is the direct or indirect action with e-learning systems. At the same time, systems provide services according to the specified strategies for activities. In other words, service specifications are e-learning activities aligned with the e-learning pedagogical models and the instructional strategies.
Conclusions and future work

In this study we construct an e-learning systems theory framework. The goal is to identify the participants, technology, and services related to e-learning.

We present a literature review on e-learning, searching for the various concepts related to the use of computers in learning contexts. This study reveals that e-learning is not the most used concept in research. In fact, researchers refer to other concepts (e.g., CAL, CFL, CAE, CBE, LMS or MOOCs). After identifying those concepts, we then report the results of a bibliometric study of the e-learning related concepts indexed by an academic search engine. We also review the e-learning dimensions, which are: the e-learning systems stakeholders, the pedagogical models, the instructional strategies, and the learning technologies. Using these dimensions we construct a theoretical e-learning conceptual framework. The resulting framework for e-learning has three dimensions: people, technology, and services. These dimensions provide our theoretical framework with a more holistic view. The main contribution of this critical literature review is to provide the theoretical background for e-learning research strategies.

The e-learning systems theory framework was constructed upon the three main components of an information system: people, technology, and services provided by technology itself. Guided by these main pillars we revise and identify the stakeholders groups and their interaction with e-learning systems. We then present the classification of the technological considerations to these kinds of system, focusing more on the contents type and ways of communication, than on providing a list of the platforms existing in the market. This is an important feature of the
framework, because apart from the commercial platforms we identify technological specifications that can be applied to any technological artifact. The third pillar corresponds to services provided by an e-learning system. Services are considered here as the main output, as they operationalize instructional strategies and several pedagogical models. The framework provides the theoretical structure for multiple studies in e-learning systems.

For future work we intend to use this framework as a cornerstone to guide our e-learning systems research. We intend to propose a model for assessing the success of e-learning systems.

References


A Path Model of Effective Technology-Intensive Inquiry-Based Learning

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ABSTRACT
Individual aptitude, attitudes, and behavior in inquiry-based learning (IBL) settings may affect work and learning performance outcomes during activities using different technologies. To encourage multifaceted learning, factors in IBL settings must be statistically significant and effective, and not cognitively or psychomotor intensive. We addressed these questions in a study of 421 students from 11 Slovenian middle schools using an experimental design. Learning achievements were measured by pre- and post-test, while IBL experiences and perceptions were surveyed in a one-shot study. IBL and its effects were successfully measured with a reliable technological literacy test. We designed a path model to capture the effects from multiple interferers. Course content was the most decisive influential factor, with strong impacts on learning achievements, satisfaction, and perceived course intensity. Prior knowledge and capacity, which affects IBL and decreases its psychomotor intensity, was a surprisingly strong influence. IBL had a large, positive effect on technological knowledge and the development of problem solving, critical thinking, and decision-making abilities. The study findings showed that the proposed IBL model is an effective teaching approach in technology-intensive education.

Keywords
Inquiry-based learning, Technology intensive, Technological knowledge and capacity, Students’ experiences and satisfaction, Path model

Introduction
Inquiry-based approaches are one of many instructional approaches that use meaningful tasks such as cases, projects, and research to situate learning. Students work in collaborative and cooperative groups to identify what they need to learn to solve a problem, gain research skills, and enhance trade-off capacity (Avsec & Kocijancic, 2014). Inquiry-based learning (IBL) is an inductive learning strategy that enables learners to construct and process knowledge, develop reasoning skills, and to increase interest and learning motivation in technology-intensive learning environments (Hmelo-Silver, Duncan, & Chinn, 2007; Minner, Levy, & Century, 2010; Marshall & Horton, 2011). Alfieri, Brooks, Aldrich and Tenenbaum (2011) stated that “allowing students to interact with materials, models, manipulate variables, explore phenomena, and attempt to apply principles affords them with opportunities to notice patterns, discover their underlying causalities, and learn in ways that are seemingly more robust” (p. 3). The effectiveness of active learning approaches is still a matter of debate at all levels of education (Galand, Frenay, & Raucent, 2012). During recent decades, even in several models of IBL, there has been a lack of reliable quantitative measurement of IBL achievements (Kirschner, Sweller, & Clark, 2006; Marshall, Horton, & Smart, 2009; Alfieri et al., 2011). The quantitative effects in terms of knowledge, problem solving, and developing critical thinking and decision-making (CTDM) capabilities are still lacking. Considering all reported features and influencers, the best IBL environments and models are yet to be discovered. The visualization of factors influencing effective technology-intensive guided IBL in middle school open learning courses is still lacking.

We contribute to the literature by providing evidence of an association between individual IBL acceptance factors (learning environment, material, process, content, reactions, and behavior), individual prior capability, and the performance (knowledge and capacity, satisfaction, and cognitive and psychomotor difficulty) in the context of the middle school inquiry-based open learning environment. Especially, scientists and educators in technology education can benefit from this.

Therefore, the objective of this paper is to investigate what factors in IBL settings encourage multifaceted learning, are statistically significant, satisfying, and effective, and are not cognitive or psychomotor intensive.
Literature review

Research on the impact of IBL on learning is timely because classroom reform discussions are exploring issues of flexible thinking and lifelong learning. Science and technology educators are increasingly interested in IBL as shown by the widespread IBL-related publications. Educators are interested in IBL because of its emphasis on active, transferable learning and its potential for motivating students. By exploiting the capacity of varied technologies, classroom- and/or laboratory-based IBL has become more attainable. Kim and Hannafin (2011) argue that the “evidence of understanding how to support students’ IBL in classroom-based, technology-intensive learning environments has been limited, and coherent frameworks to guide implementation have been slow to emerge” (p. 1). Recent efforts by many researchers (e.g., Eisenkraft, 2003; Prince & Felder, 2006; Minner et al., 2010; Marshall & Horton, 2011) showed that IBL was especially attractive to the science community, but the effectiveness of IBL is not yet stable in real-world classrooms using technology-intensive learning environments. Investigations of scaffolding learning in real-world classrooms are scarce (Kim & Hannafin, 2011). IBL has been recommended as a leading instructional strategy for science, but has several limitations in technology-intensive education (Prince & Felder, 2006; Moutrakis & Triantakonstantis, 2012). These limitations are in the instructional materials, learning-process planning used, and the assessment, motivation, and the measurement of metacognitive reflection.

IBL is a learner-centered approach where critical thinking, problem solving, and communication abilities are more important than simply having knowledge about the content of learning (Eisenkraft, 2003; Goldston, Day, Sundberg, & Dantzler, 2010). IBL is a multifaceted activity that uses many methods to collect and analyze data and information, and compares concepts with results to acquire and construct knowledge (Eisenkraft, 2003). IBL requires assumptions to be identified using critical and logical thinking and decision-making with trade-off capacity. IBL may take several forms, including analysis, problem solving, discovery, and creative thinking activities (Saunders-Stewart, Gyles, & Shore, 2012). IBL was developed in response to the perceived failure of more traditional forms of instruction, where students were required simply to memorize fact-laden instructional materials (Hmelo-Silver et al., 2007). IBL is a form of inductive pedagogy, where progress is assessed by how well students develop experimental, analytical, creative, and reflective skills rather than by how many competences they possess (Marshall et al., 2009). Effective IBL implementation is demonstrated through students' performance as formulation of good questions, identification and collection of physical evidence, systematic presentations and elaborations, resolving misconceptions, and management of concept transference (Levy, 2012).

Several types of IBL are discussed in the literature, and they are primarily based on three important qualifiers about the nature of inquiry: the level of scaffolding (amount of learner self-direction), the emphasis of learning, and its scale (within-class, within-course, whole-course, and whole-degree) (Kim & Hannafin, 2011). All IBL models emphasize the following levels of inquiry that differ from one another in significant ways (Minner et al., 2010; Marshall & Horton, 2011; Levy, 2012): (1) confirmation inquiry, (2) structured inquiry, (3) guided inquiry, (4) open inquiry, and (5) blended inquiry. Well-designed IBL environments can enhance students' learning experiences (Goldston et al., 2010; Moutrakis & Triantakonstantis, 2012). IBL tends to improve students’ self-regulated learning abilities, but optimal guidance during instruction has to be provided for effective IBL (Kirschner et al., 2006; Goldston et al., 2010; Segedy, Biswas, & Sulcer, 2014). Improvement of transferable skills such as teamwork, independent learning, and problem solving skills in a real-world situation can hopefully improve critical thinking, problem solving, and reduce time pressure in other technology-intensive courses (Segedy et al., 2014). A technology-intensive course engages students in the use of different technologies (production, information, or measurement), and is defined by the following outcomes where students should understand several technology qualifiers and impacts in order to be able to use, judge, assess, and manage different technologies (Garmire & Pearson, 2006; Goldston et al., 2010).

When designing an IBL course, teachers and course designers are faced with several qualifiers of real-world classroom scaffolding learning in order to affect students’ experience, knowledge construction and processing, and acquiring skills. Decisions related to the didactic design of a course may refer to one of six fields of IBL:

- Prior knowledge and capacity – Prior knowledge, problem solving, and research skills are crucial for the level of student engagement in IBL. Prior knowledge affects students’ process and content knowledge, while prior skills provides better results in metacognitive reflection (Marshall et al., 2009). Prior capacity may reduce perceived course difficulty, and ensure students’ course satisfaction (Avsec, Rihtaršič, & Kocijancic, 2014).
- Context – Learners acquire meaning from experience. Therefore, an IBL technology-intensive environment requires multiple resources, access to data, sufficient room for equipment and individual as well as group

- Content and learning materials – Active investigations, critical thinking, and reflection provide opportunities for rich interaction with the learning materials. Therefore, students achieve a deep understanding of the content and are better able to apply knowledge and skills (Manconi et al., 2008; Levy, 2012). Multiple forms of learning materials, clear learning objects and objectives, and updated and actual learning materials exploit students’ learning styles to enhance higher-order thinking skills (Garmire & Pearson, 2006) and increase students’ perceived satisfaction with the course (Avsec, Rihtaršič, & Kocijancic, 2014). The structure and coherence of the curriculum and the learning materials are a major factor for facilitating meaningful learning. The quality of the learning environment and the ease of using an open learning system also contribute to the success and course satisfaction of an IBL course (Prince & Felder, 2006; Avsec, Rihtaršič, & Kocijancic, 2014).

- Process – Activities are guided by students’ curiosity and interests, through which they acquire information-processing skills (e.g., critical thinking) that can be generalized across subject domains (Manconi et al., 2008). A well-tailored process allows students to develop self-efficacy where their belief in their own efficacy positively influences their learning achievements and persistence related to specific instructional tasks (Prince & Felder, 2006).

- Strategy of reactions and behavior – Problem solving, planning, organizational, and self-regulation strategies endow students with the skills to perform self-guided and collaborative investigations. Fluid and reflective processes are used instead of linear or cookbook approaches (Manconi et al., 2008; Levy, 2012). Such learning self-regulation is an important characteristic of students’ motivation and self-efficacy (Robbins, Lauver, Le, Davis, Langley, & Carlstrom, 2004). Student demographics (age, sex) are considered very important during the planning of course difficulty, especially in randomly chosen samples from different cohorts of students, based on what frequently happens in open learning environments.

- Course Outcomes – Course outcomes may refer to cognitive, emotional, and psychological variables. Learning achievements are considered most important in cognitive variables, which can be described as different facets of competences such as theoretical and methodical knowledge as well as the skills required for problem solving, personal/social competences (e.g., in self-regulated or collaborative learning), and/or technological competence (Garmire & Pearson, 2006; Galand et al., 2012). In emotional variables, student satisfaction with a course is an important outcome that influences the student’s decision to continue or drop out of a course (Levy, 2012; Avsec, Rihtaršič, & Kocijancic, 2014). Psychological variable outcomes are based on the perceived difficulty of the course, difficulty of cognitive processing, and the course’s psychomotor intensity (Robbins et al., 2004).

New IBL model

Several IBL models circulate in the literature, but three models proved to be effective and were most suitable for this research. Eisenkraft’s (2003) 7E model and Marshall, Horton and Smart’s (2009) 4E×2 model are most frequently used in science education. The 7E model emphasizes the increasing importance of eliciting prior understandings and the extending or transfer of concepts as transferable competences (Eisenkraft, 2003). Marshall et al.’s (2009) 4E×2 model should be seen as a dynamic IBL model. It allows also formative assessment, use of different inquiry instructional methods, and metacognitive reflection (Marshall et al., 2009). The essential weaknesses (summative assessment and metacognitive reflection) of both models were overcome by a recently developed model by Avsec and Kocijancic (2014). This new model providessummative assessment, active metacognitive reflection, and several feedback mechanisms and assessment through a newly implemented phase of explicit diagnostics and modeling (Figure 1). Metacognitive reflection learning becomes central in all stages of inquiry in this model instead of only in the latter stages of the process. Marshall et al. (2009) argue that when metacognitive reflection and formative assessment are integrated in IBL, teaching becomes more informed and students have more opportunities to monitor their progress in relation to their intended goals.

During the modeling and explicit diagnostics phase, students were engaged in the experiment design and construction to increase the usability of existing experiments. The diagnostics phase combined with the creative-thinking method 635 aimed for multiparametric problem solving and also to boost students’ creativity. The course content was enriched with self-made real-world components and models as data sources that were assumed to impact learning achievements (Goldston et al., 2010; Galand et al., 2012), improve the self-regulation process (Marshall et al., 2009), and decrease the physical and cognitive difficulty of the course (Avsec, Rihtaršič, & Kocijancic, 2014).
Research showed that single and linear outcomes and/or effects of IBL in technology-intensive education were investigated, but complex impacts are unknown. The complex interactions of IBL in technology and engineering education may be demonstrated through technological literacy, where the learning effects in technology-intensive open learning have not yet been measured. Briefly, clear empirical evidence on how different fields of guided IBL interact is still lacking. Insights into the interaction of influential factors in IBL could be useful to design effective programs for open learning in science and technology education.
In this study, we empirically investigated the interrelation of different factors of technology-intensive IBL, such as aptitude, attitude, behavior, demographics, learning achievements, satisfaction, and learning difficulty. As Zion and Mendelovici (2012) concluded in their earlier literature review, student aptitude is found to affect learning achievements and, in turn, is supposed to affect students’ perceived learning difficulty. Moreover, it is assumed that students’ attitude or behavior in IBL positively affects their satisfaction, learning achievements, and learning difficulty (Segedy et al., 2014) while students’ demographics (age or sex) could be decisive in IBL achievements and perceived difficulty (Robbins et al., 2004). Hypothesized relations are presented schematically in Figure 2.

Methodology

Research design and the sample

We used an experimental research design to investigate the effectiveness of IBL. This study design used two groups: a control group and treatment group. One group was educated using IBL in an open learning course of technology education consonant with the research recommendations on learning and instruction from a cognitive science perspective (Prince & Felder, 2006). The control group received no IBL in technology and engineering education instruction. Prior knowledge and learning achievements were measured pre- and posttest. Other outcomes such as emotional (satisfaction with the course) and psychological (perceived course difficulty) were surveyed only in the treatment group.

The sample for experimental study was drawn from middle school students. Treatment group students ($n_T = 91$) were enrolled in an IBL open course of technology education at five middle schools. Control group students ($n_C = 338$) were not enrolled in IBL at six middle schools. The middle schools recruited in this study were selected by IBL role models (3 university scientists, 3 applied science researchers, 3 young researchers) to assure methodological and IBL requirements. Middle schools recruited in this study had similar demographics (sex or age), a cohort with at least 60–80 students, and social learning skills were needed for the treatment group. IBL was performed from November 2013 to March 2014. The entire course was 3 days long (15 periods). Pre- and post-test surveys were distributed accordingly. The majority ($n = 421$) of the enrolled students completed the test both times. The participants’ sexes were evenly distributed: 50% ($n_F = 211$) females and 50% ($n_M = 210$) males (1.8% missing values, $n = 8$). Students were aged 14 ± 1 years. A treatment group were 56 female students (61%) and 35 males (39%).

Instruments

Learning achievements of IBL can be described as different facets of competencies. A holistic method for measurement of technological literacy is proposed for exploring the multifaceted nature of constructs or phenomena (Garmire & Pearson, 2006; Avsec & Kocijancic, 2014). For this purpose, researcher-developed technological literacy multiple-choice test was administered to the students. The test items (TI) were validated by an expert panel. The experts who were selected to serve as content-validation experts were university professors and middle school teaching experts. Evidence of content validity was provided by expert review. Identical versions of the 15-item test were presented at pre- and post-test; the test was subdivided into three subscales based on the subject matter (explicit and implicit) of hydraulic turbines, with five items in each subscale: (1) technological knowledge; (2) problem-solving capabilities; and (3) CTDM abilities. TI examples to measure the achievement of learning objectives in IBL were described elsewhere by Avsec and Kocijancic (2014) while the method for TI construction was described by Avsec and Jamšek (2015).

Student experiences, satisfaction, and perceived course difficulty were considered important for the long-term success of IBL open learning courses. For this purpose, a researcher-developed questionnaire addressing the specifics of the course offerings was administered to the students. The survey items were validated by an expert panel. The expert content validators were university professors and middle school technology teacher experts. An expert panel provided evidence of survey content validity. The survey consisted of five groups of questions with four items, and of three groups of questions with two items in each group. Instrument development was required for the factors affecting the IBL process. For the assessment, a 7-point phrase completion scale was used. The scale intervals form a continuous type from minimum (1) to maximum (7). The scale does not present the mean, but ensures the
comparability of continuous responses and produces better assumptions of parametric statistics while avoiding bias (Hodge & Gillespie, 2007).

Data collection

Students participated in the study during real-world classroom sessions throughout a school day. The treatment group students participated in IBL in small groups of 3–4 students (6 groups at the class level) while the control group students had no specific treatment for subject matter except regular traditional lessons. After completion of the pretest, all treatment group students were engaged in 3 days of IBL activities. Administration of the post-test surveys was performed depending on the school curriculum and activity plan, see Table 1.

<table>
<thead>
<tr>
<th>Middle school</th>
<th>Pilot test</th>
<th>Experimental group</th>
<th>Control group</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre-test</td>
<td>Post-test</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Day 1</td>
<td>Day 2</td>
<td>Day 3</td>
</tr>
<tr>
<td></td>
<td>Pre-test+</td>
<td>IBL</td>
<td>IBL+</td>
</tr>
<tr>
<td></td>
<td>IBL</td>
<td></td>
<td>Post-test + Survey</td>
</tr>
<tr>
<td>Gorenjskem</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Brestanica</td>
<td></td>
<td>4.2.2014</td>
<td>2.4.2014</td>
</tr>
<tr>
<td>Sežana</td>
<td>15.1.2014</td>
<td>14.3.2014</td>
<td></td>
</tr>
<tr>
<td>Kranj</td>
<td>21.1.2014</td>
<td>27.3.2014</td>
<td></td>
</tr>
</tbody>
</table>

Data analysis

Data analysis was conducted using SPSS. In case of the multidimensionality or heterogeneousness of the test, Cronbach’s alpha was not suitable as a reliability coefficient (Rossiter, 2010). Therefore, the test–retest reliability was calculated by comparing the scores of 47 students who filled out the test during the first study (September 2013) and again during the second study (November 2013). The intraclass correlation coefficient (ICC) was used as a measure of correlation to contrast with Pearson \( r \) correlations (Weir, 2005). To support the criterion-related validity of the test, a corrected Pearson \( r_{xy} \) coefficient was used. A corrected Pearson \( r_{xy} \) coefficient is an appropriate measure of criterion-related validity (Rossiter, 2010), which served to verify concurrent and predictive validity (Odom & Morrow, 2006). For the purpose of this study, convergent and discriminant validity were assessed by performing an exploratory factor analysis (EFA). However, two criteria were considered to ensure an appropriate sample size was obtained for the current study to enable factor analysis to be undertaken: (a) Kaiser–Meyer–Olkin (KMO) sampling adequacy; and (b) factor loadings and the correlation between a variable and a factor (Stevens, 2009). To demonstrate convergent validity, magnitude of the direct structural relationship between the item and factor should be statistically different from zero (Stevens, 2009). As for discriminant validity, factor correlation matrix analysis has been employed in this study. This method checks the estimated correlations between the factors.

Descriptive analyses were conducted to identify basic information about the students. A two-way analysis of variance (ANOVA) was used to find within-subjects contrasts. We conducted a \( t \)-test analysis to find and confirm significant relationships between groups with an effect size calculated with Glass’s \( \Delta \). We conducted a structural equitation modeling using AMOS software for joint effects of multiple interferers. To uncover the causal relations between the different IBL dimensions, a path model was defined and tested as follows: Outcomes were hypothesized to be influenced by students’ prior aptitude, attitude towards learning format, behavior/reactions, and demographics.
Results

Student performance

The reliability of the test was assured by test and retest scores that correlated significantly (Pearson $r_{xy} = 0.877; p < 0.01$). The ICC measure (0.93; $p < 0.01$) depicts the strong reliability of the test over time. A high ICC provides a minimum of misclassifications in the measurement of the heterogeneous and complex nature of the construct (Weir, 2005). Correlation analysis of TIs revealed that TIs were negligible (0.01 $< r_{xy} < 0.19$) and weakly correlated (0.19 $< r_{xy} < 0.29$) (Rossiter, 2010) because they were measuring different benchmarks. A low value of the Pearson correlation coefficient ($r_{xy} < 0.29$), demonstrates that all TI were solidly designed and constructed and each TI measures exactly what it was designed for. We provided evidence of high criterion-based validity; therefore, the high concurrent and predictive validity of the results was verified (Odom & Morrow, 2006).

All significance tests for the results were two-tailed. Descriptive statistics for the pre- and post-tests are shown in Table 2. The descriptive data and the comparison of measures of central tendency show that the $(14 \pm 1)$-year-old students taking IBL scored higher on the technological literacy test (mean ($M$) = 5.03; standard deviation ($SD$) = 1.85) than those who had no previous IBL exposure ($M = 3.22$; $SD = 1.65$). The results indicated a low overall score (maximum of 15), which depicts the high TI difficulty. The test was designed for a 3-year longitudinal study of IBL effects in technology education and it will be exploited in the next 2 years. Further descriptive analysis indicated that the test for homogeneity of variance was nonsignificant, which meant that the sample exhibited characteristics of normality required for analysis under the assumptions of the general linear model. Levene’s test for equality of variances achieved no statistical significance at pretest ($F(1,419) = 3.03, p = 0.09 > 0.05$), while the $t$-test revealed no statically significant differences ($t(419) = -0.57, p = 0.57 > 0.05$), and at post-test ($F(1,419) = 3.4, p = 0.07 > 0.05$) with $t$-test ($t(419) = 8.98, p = 0.00 < 0.05$).

<table>
<thead>
<tr>
<th>Test</th>
<th>Group</th>
<th>Number of students</th>
<th>$M$</th>
<th>$SD$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pretest</td>
<td>Treatment</td>
<td>91</td>
<td>3.02</td>
<td>1.56</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>330</td>
<td>3.12</td>
<td>1.44</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>421</td>
<td>3.09</td>
<td>1.46</td>
</tr>
<tr>
<td>Post-test</td>
<td>Treatment</td>
<td>91</td>
<td>5.03</td>
<td>1.85</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>330</td>
<td>3.22</td>
<td>1.65</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>421</td>
<td>3.61</td>
<td>1.85</td>
</tr>
</tbody>
</table>

A two-way within-subject ANOVA was performed to test how IBL enhances learning in a treatment group. Statistically significant positive impacts were found. IBL statistically significantly effects on learning and skills acquisition ($p < 0.01$) with a positive and large effect size ($\eta^2 = 0.38$). Learning differences were also checked using a $t$-test where significances were revealed ($F(1,419) = 110.17, p = 0.00$) and equal variances were not assumed ($t(99) = 9.24, p = 0.00 < 0.05$). Considering unequal sample sizes and variances, we randomly sampled the data of the control group to equalize the samples ($F(1,180) = 41.35, p = 0.00$ and $t(119) = 9.42, p = 0.00$), while the effect size of Glass’s $\Delta = 1.11$ confirms the large effect of IBL. The effect size value should be interpreted cautiously. The small-group learning methods implemented at IBL could increase learning achievement in technology and engineering education with an overall average effect-size of 0.25 (Springer, Stanne, & Donovan, 1999). The different size of the groups at IBL could affect results; the effect size is regarded as small (Springer et al., 1999). The sample size of the two research groups had no influence on the results. No differences were found across the sex distribution ($F(1,419) = 0.64, p = 0.42 > 0.05$ and $t(419) = 0.36; p = 0.72$).

Student experiences, perceptions, and satisfaction

The findings from literature review revealed subscales for technology-intensive IBL. After revision of the survey, there were four items in each subscale; two items were for overall satisfaction, learning difficulty, and psychomotor intensity as the perceived outcomes of the course. A reliability analysis was performed after administering the survey. The Cronbach’s alpha values indicated that the developed instrument was highly reliable for the majority of
designed and students considered its difficulty to be moderate. The course was well structured and multiple forms of learning material that present a rich data source were ranked high (M = 4.70, SD = 1.47). The component with the lowest ranked perceived experiences was physical learning environment (M = 3.66, SD = 1.1). Students needed more room for effective IBL (M = 4.70, SD = 1.47) while the feedback on IBL and multiple forms of learning material that present a rich data source were ranked high (M = 6.18, SD = 1.02 and M = 6.06, SD = 1.34, respectively). Table 3 shows that we can conclude that there is a high level of overall student satisfaction with the course because students felt comfortable with all sections of IBL. The course was well designed and students considered its difficulty to be moderate.

### Table 3. Reliability information and descriptives about survey subscales and items (n = 91)

<table>
<thead>
<tr>
<th>Items</th>
<th>Cronbach’s alpha</th>
<th>M</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experiences concerning learning environment (LE)</td>
<td>0.89</td>
<td>5.03</td>
<td>1.28</td>
</tr>
<tr>
<td>LE1– Classrooms and laboratories are well equipped and organized</td>
<td></td>
<td>4.80</td>
<td>1.46</td>
</tr>
<tr>
<td>LE2– Learning environment is user friendly</td>
<td></td>
<td>5.17</td>
<td>1.64</td>
</tr>
<tr>
<td>LE3– Each student has enough room for research and creative work</td>
<td></td>
<td>4.70</td>
<td>1.47</td>
</tr>
<tr>
<td>LE4– Refreshment and snacks are available, easy on access</td>
<td></td>
<td>5.50</td>
<td>1.31</td>
</tr>
<tr>
<td>Experiences concerning learning material (LM)</td>
<td>0.81</td>
<td>5.82</td>
<td>0.93</td>
</tr>
<tr>
<td>LM1– Learning material is up to date and actual</td>
<td></td>
<td>5.57</td>
<td>1.34</td>
</tr>
<tr>
<td>LM2– Material gives enough information for inquiry</td>
<td></td>
<td>6.06</td>
<td>1.34</td>
</tr>
<tr>
<td>LM3– Learning objectives are clear and well designed</td>
<td></td>
<td>5.94</td>
<td>0.84</td>
</tr>
<tr>
<td>LM4– Learning material was of multiple forms and types</td>
<td></td>
<td>5.67</td>
<td>1.07</td>
</tr>
<tr>
<td>Experiences concerning learning process (LP)</td>
<td>0.84</td>
<td>5.77</td>
<td>0.93</td>
</tr>
<tr>
<td>LP1– Active learning and practical work are enabled</td>
<td></td>
<td>5.93</td>
<td>1.06</td>
</tr>
<tr>
<td>LP2– Assistance, self-directed and collaborative work are enabled</td>
<td></td>
<td>5.76</td>
<td>1.21</td>
</tr>
<tr>
<td>LP3– I was effective, no need for extra help or teacher guidance</td>
<td></td>
<td>5.59</td>
<td>1.11</td>
</tr>
<tr>
<td>LP4– Explanations and instructions were clear and comprehensible</td>
<td></td>
<td>5.81</td>
<td>1.15</td>
</tr>
<tr>
<td>Experiences concerning reactions and behavior (RB)</td>
<td>0.68</td>
<td>5.39</td>
<td>0.98</td>
</tr>
<tr>
<td>RB1– Learning was effective and success controlled via tests</td>
<td></td>
<td>5.40</td>
<td>1.63</td>
</tr>
<tr>
<td>RB2– Learning was creative, own ideas were well considered</td>
<td></td>
<td>5.52</td>
<td>1.40</td>
</tr>
<tr>
<td>RB3– Own learning pace was enabled</td>
<td></td>
<td>5.72</td>
<td>1.40</td>
</tr>
<tr>
<td>RB4– I can recommend this IBL to fellow students</td>
<td></td>
<td>4.93</td>
<td>0.94</td>
</tr>
<tr>
<td>Experiences concerning content (C)</td>
<td>0.86</td>
<td>5.82</td>
<td>1.01</td>
</tr>
<tr>
<td>C1– Content is attractive, interesting, suits for males and females</td>
<td></td>
<td>5.67</td>
<td>1.46</td>
</tr>
<tr>
<td>C2– Different feedbacks are enabled</td>
<td></td>
<td>6.18</td>
<td>1.02</td>
</tr>
<tr>
<td>C3– Language was clear, subject matter content was comprehensible</td>
<td></td>
<td>5.56</td>
<td>1.10</td>
</tr>
<tr>
<td>C4– Content was well organized and timely fashion over all IBL days</td>
<td></td>
<td>5.86</td>
<td>1.16</td>
</tr>
<tr>
<td>Experiences concerning satisfaction (S)</td>
<td>0.82</td>
<td>5.61</td>
<td>0.84</td>
</tr>
<tr>
<td>S1– Overall satisfaction with the IBL teachers</td>
<td></td>
<td>5.56</td>
<td>0.87</td>
</tr>
<tr>
<td>S2– Overall satisfaction with the course model</td>
<td></td>
<td>5.66</td>
<td>0.82</td>
</tr>
<tr>
<td>Experiences concerning cognitive difficulty (CD)</td>
<td>0.90</td>
<td>3.61</td>
<td>1.17</td>
</tr>
<tr>
<td>CD1– I find it difficult to memorize fact-laden materials</td>
<td></td>
<td>3.54</td>
<td>1.14</td>
</tr>
<tr>
<td>CD2– I find it difficult to think and to learn new content and concepts</td>
<td></td>
<td>3.68</td>
<td>1.22</td>
</tr>
<tr>
<td>Experiences concerning psychomotor intensity (PI)</td>
<td>0.84</td>
<td>3.69</td>
<td>0.97</td>
</tr>
<tr>
<td>PI1– I find it difficult to concentrate myself at design activities</td>
<td></td>
<td>3.54</td>
<td>1.01</td>
</tr>
<tr>
<td>PI2– I find it difficult to handle with tools and workshop equipment</td>
<td></td>
<td>3.84</td>
<td>0.94</td>
</tr>
</tbody>
</table>

### Path model

A path model consists of student performance variables (knowledge, capacity, and CTDM) and variables describing students’ perception, experiences and satisfaction. EFA provided evidence of construct validity on the model variables. To ensure an appropriate sample size to undertake factor analysis, the value of KMO sampling adequacy on the survey and test was 0.78 and Bartlett’s test of sphericity was significant (p = 0.00 < 0.05). The sampling
adequacy value of 0.78 for the model variables was very good (Stevens, 2009). On the first-run principal component analysis (PCA), the total variance of the model factors was 71% (seven factors, eigenvalue >1). The communalities \( h^2 \) of the all variables on the model were >0.4. The decision to eliminate low-loading variables was confirmed using Steven’s (2009) guidelines of statistical significance for interpreting factor loadings. Steven’s (2009) guidelines are based on sample size and suggest that the statistically acceptable loading for 91 participants is 0.52. The structure matrix revealed valid variables, which provide evidence of the convergent validity of factors (Table 4). A factor correlation matrix was also calculated where there were very low values of correlations between seven factors and correlations did not exceed 0.36 < 0.7. These factors are distinct and uncorrelated, which shows the high discriminant validity of factors (Stevens, 2009).

<table>
<thead>
<tr>
<th>Variable</th>
<th>Component 1</th>
<th>Component 2</th>
<th>Component 3</th>
<th>Component 4</th>
<th>Component 5</th>
<th>Component 6</th>
<th>Component 7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prior knowledge</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.75</td>
</tr>
<tr>
<td>Prior capabilities</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>−0.84</td>
</tr>
<tr>
<td>Prior CTDM</td>
<td></td>
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<td></td>
<td>0.81</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Post CTDM</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.83</td>
<td></td>
</tr>
<tr>
<td>LE1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.85</td>
<td></td>
</tr>
<tr>
<td>LE2</td>
<td>0.54</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LE3</td>
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<td></td>
</tr>
<tr>
<td>LE4</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td>0.84</td>
</tr>
<tr>
<td>LM1</td>
<td>0.64</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>LM2</td>
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<td>0.83</td>
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<td></td>
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</tr>
<tr>
<td>LM3</td>
<td>0.56</td>
<td>−0.55</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>LM4</td>
<td>0.86</td>
<td></td>
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</tr>
<tr>
<td>LP1</td>
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<tr>
<td>LP2</td>
<td>0.68</td>
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<td>−0.52</td>
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</tr>
<tr>
<td>LP3</td>
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<tr>
<td>LP4</td>
<td>0.75</td>
<td></td>
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<td></td>
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<td>−0.58</td>
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</tr>
<tr>
<td>RB1</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td>−0.86</td>
</tr>
<tr>
<td>RB2</td>
<td>0.53</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>−0.64</td>
<td></td>
</tr>
<tr>
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<td></td>
<td>−0.80</td>
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</tr>
<tr>
<td>RB4</td>
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<td></td>
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<td></td>
<td></td>
<td></td>
<td>−0.55</td>
</tr>
<tr>
<td>C1</td>
<td></td>
<td>−0.68</td>
<td></td>
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<tr>
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<td></td>
<td></td>
<td></td>
<td>0.84</td>
<td></td>
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</tr>
</tbody>
</table>

Many researchers argue that the most decisive and important variable influencing IBL outcomes might be content (Eisenkraft, 2003; Prince & Felder, 2006; Galand et al., 2012; Levy, 2012). Until now, clear empirical evidence was still lacking. Our research design also provided covariates on students’ demographics and we constructed a path model of effective IBL outcomes that are influenced by independent variables. Model fit tests were done in AMOS software, and a path model of IBL dimensions with statistical significant \( p < 0.05 \) standardized path coefficients is shown in Figure 3. Exogenous entries in model were sex, age, prior aptitude, learning environment, material and
process, reactions and behavior, and content, while endogenous variables were knowledge and capacity, satisfaction, and perceived course difficulty and intensity. All exogenous variables (except sex) effects were hypothesized to be significantly correlated with both positive and negative outcomes.

Figure 3 illustrates the path model after the attenuation correction. IBL outcomes are influenced by variables with significant standardized path coefficients ($p < 0.05$). According to commonly used fit indices (Schermelleh-Engel, Moosbrugger, & Müller, 2003; Blunch, 2013), we found that the fit of this model was very close. A nonsignificant $p$-value (0.57) was observed from the Chi-squared test (16.4), and the Chi square divided by its degrees of freedom was smaller than 5 (0.91). The Goodness of Fit Index, the Comparative Fit Index, and the Tucker–Lewis Coefficient values were larger than 0.95 (0.97, 1.00, and 1.01, respectively), and the root mean-squared error of approximation and the root mean square residual were smaller than 0.05 (0.00 and 0.04, respectively). The probability of close fit was larger than 0.05 (0.77). The probability level of the test of close fit was also higher than the proposed threshold level of 0.50 for a good model fit (Blunch, 2013). This indicates a great initial model that does not need any improvement. All paths in the model showed significant effects.

The significant path coefficients varied from medium (0.16) to strong (0.59) and the absolute rate was considered. The variance in IBL learning achievements was explained by influencing variables in 51.6%. The most influential variables were prior knowledge and capacity and IBL content. ANOVA revealed most of the important factors influencing learning achievements. Prior practice and problem-solving skills have the largest positive effect ($p = 0.00$, $\eta^2 = 0.45$). Prior CTDM and clarity of language and subject matter material impacts significantly on learning achievements with a large effect size $\eta^2$ (0.24 and 0.23, respectively). In student satisfaction, 85.3% of the variance was explained by learning environment, material, and process, and by the reactions and behavior and content variables in this model. ANOVA revealed that all variables that were correlated with satisfaction have a uniform effect with no statistically differences between each other ($p > 0.05$). The variance of perceived cognitive processing difficulty was explained for 48.6% by learning process and content. ANOVA revealed the most decisive factor with a large effect size, which shows that good organization of the content makes the IBL course easier ($p = 0.01 < 0.05$, $\eta^2 = 0.22$). The high variance in psychomotor intensity was explained for 40.3% by student age, content, learning
process, and prior learning practice (knowledge and capacity). The psychomotor intensity might decrease with prior practice (capabilities) and interesting content, which was shown evenly in male and female sexes ($p = 0.00, \eta^2 = 0.53$ and $p = 0.02, \eta^2 = 0.23$, respectively).

Seven path coefficients had negative estimates. The negative path coefficient for the Learning environment to Learning achievements path orientation means that a highly comfortable learning environment predicts a less-effective IBL. Thereafter, organized, clear, attractive content with enabled feedback mechanisms, and a well-designed learning process decrease the learning difficulty and psychomotor intensity of the course. Prior practice and older students show that the psychomotor intensity of the technology-intensive IBL is easier. The explained variances were calculated using $R^2$ from path model where $R^2 = 0.02$ means a small impact, $R^2 = 0.13$ means a medium effect size, and $R^2 = 0.26$ presents a large effect size (Cohen, Cohen, West, & Aiken, 2003).

**Discussion**

The path model of factors influencing course outcomes shows that prior knowledge affects only knowledge acquisition and reduces psychomotor intensity. The physical learning environment improves students’ learning and satisfaction, but learning materials influenced only student satisfaction with the course. The learning process influences satisfaction and reduces course difficulty. Students’ interactions in scaffolding learning influence satisfaction while content influences all IBL outcomes significantly. The path analysis of factors affecting IBL shows that content is an important influential factor for new knowledge and capacity as well as for the perceived difficulty of the course.

Surprisingly, student age showed low influence; it provided a reduction of course psychomotor intensity. According to previous IBL research, the CTDM component was judged decisive (Manconi et al., 2008, Segedy et al., 2014). Our case revealed a high level of teacher scaffolding and less student involvement. Interactions were not decisive in reducing course difficulty beyond what was expected in open learning systems (Avsec, Rihtaršič, & Kocijancic, 2014). Different feedback mechanisms and prior aptitude were decisive for reducing course difficulty (Segedy et al., 2014) and improving metacognition and higher-order thinking (Marshall & Horton, 2011), which were reflected in increases in knowledge and capacity (Avsec & Kocijancic, 2014). Multiple forms of learning materials seem less decisive in the acquisition of knowledge and skills (Kim & Hannifin, 2011; Levy, 2012) or in perception of difficulty (Hmelo-Silver et al., 2007). CTDM was not developed properly even after several interactions and reflective examination of student’s scaffold learning, which again proves that student self-regulation is not a good predictor of course quality. A surprisingly negative and large correlation was found in the learning environment’s effects on learning achievements. We can conclude that a well-equipped and comfortable learning environment might decrease the learning achievements for guided self-directed inquiry in technology education.

**Conclusion**

Only a well-tailored experimental design can produce reliable, valid, and accurate results. The IBL model presented in this study has had positive and large influence on the development of learning achievements. Technology-intensive IBL shows good predisposition in terms of skills and prior knowledge, decreased course intensity (psychomotor and cognitive), and enhanced learning. The path model shows that all path coefficients have a medium to strong effect on course outcomes and should be considered very carefully if we want to make technology-intensive inquiry effective.

In a well-equipped learning environment, a full open inquiry is not recommended for middle school students because it can produce many misconceptions. In that case, we suggest more teacher involvement in guided inquiry or an implementation of structured inquiry. Different feedback mechanisms must be enabled. Our evidence and metrics about effective IBL will contribute significantly to technology educators. Some limitations could consist of the quality of the program, teacher effects, and how the students perform in traditional academic courses. Further research is required to replicate these findings amongst other samples, and to identify whether there are specific variations in IBL practices and styles that are particularly salient to the development of students’ problem-solving and CTDM abilities.
References


A Field Study of a Video Supported Seamless-Learning-Setting with Elementary Learners

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ABSTRACT

Seamless Learning shall initiate human learning processes that exceeds lesson and classroom limits. At the same time this approach fosters a self-regulated learning, by means of inspirational, open education settings. Advanced learning materials are easily accessible via mobile digital devices connected to the Internet. In this study it was explored whether and to what extent an open learning approach can be initiated by support of videos and incentives. The study took place in a real-world setting during a conventional mathematics class in an Austrian secondary school with \( N = 85 \) children of average age of 10, 6 years. For the investigation a traditional face-to-face maths-teaching environment was completely replaced by an open learning environment. In our study, the elementary learners were able to select their own learning pace and preferences via example videos. In addition to the use of an open education approach and videos, their learning was also incentivised via a reward system of “stars.” A pre-test-post-test-control-group study showed that the learning performance significantly increased. The reason was due to the combination of a novel teaching and learning setting and coupled incentives to foster the learning process.

Keywords

Open education, Mathematics, Elementary learners, Video, Seamless learning

Introduction

Developing a seamless real-world learning setting using open learning and video in primary maths education

Ideally, learning should be a seamless flow across context (Wong & Looi, 2011) and therefore be possible anywhere and anytime in many different scenarios (Ally et al., 2014). Nevertheless, “seamless learning” is much more than just using (mobile) technologies to assist and enhance learning. It could also be described as a learner’s frame of mind that should not be taken for granted (Chan et al., 2006; Wong & Looi, 2011).

Nevertheless there is not much related work available in our particular area, so we have to emphasize that the combination of the seamless learning concept with mathematics in a real-world study is novel. In a very recent work Schmitz et al. (2015) report about a mobile game application where children play an active role in the simulation of a dynamic process and followed also a design-based research approach and demonstrated that mobile game-based learning environments can productively support seamless learning activities for children, although they also reported - and that is in line to our experience - that the approach to seamless learning design is difficult to achieve; nevertheless they emphasize also that it can help us to bridge the gap between learning both in physical and digital worlds. Moreover, Muñoz-Cristóbal et al. (2014) emphasize that most previous projects have limited support to the connection of learning activities across spaces, which can be exemplified fundamentally by the flow of artefacts between activities conducted in different spaces, which is similar to our approach. Guided by design-based research and the notion of seamless learning, Sollervall et al. (2012) have designed a learning activity in mathematics with mobile computer support of transitions between different learning contexts. A different approach in medical education was implemented by Bloice et al. (2014).

Although this contribution focuses on the evaluation and investigation of our new learning setting, its development itself was a first important step. In contrary to traditional research-questions driven investigation on a theoretical base, a “design-based research” approach is a means to develop an educational setting that fits to a specific “real world” challenge using existing theoretical and empirical knowledge (Brown, 1992; Collins, 1992). “The ultimate
goal of design-based research to build a stronger connection between educational research and real-world problems” (Amiel & Reeves 2008, p. 34, see Figure 1)

Building on this approach we analysed the practical challenges of an Austrian math teacher in elementary school, when (s)he wants to implement a seamless real-world learning setting with elementary learners. To initiate seamless learning an open learning approach as well as an individual usage of mobile devices is central. Pragmatically, our possibility to implement and analyse a variation of the traditional learning setting was limited: It had to build on the curriculum and the covered topics in the textbook, it had to be limited to a set of lessons in one discipline and it had to address the prior learning and teaching experiences and equipment of pupils as well as teachers.

Our discussions lead to the idea to develop an open learning setting with worked example video podcasts on the topic “circle.” “Open education” practice means that learners are permitted and motivated to select learning paths and learning references according to their personal needs and interests inside the classroom. There is a large variety of approaches of open education practices. The “openness” of such settings refers to the possibility to choose certain learning activities and even sometimes learning goals by the learner. Such learning is also known as self-regulated learning and gained attention in the realm of educational research (Wang, 2011; Kauffman, 2004). Interestingly especially in the field of mathematic instruction many studies over the last decades have pointed out that open learning approaches – e.g., problem-based learning, project-based learning or the Montessori Method – are not only associated with more student achievement and academic success (Lopata et al., 2005), but also to be more effective than traditional methods in teaching mathematics (Kazemi & Ghoraishi, 2012).

The “open education” approach in our setting at this stage was the idea of developing learning materials and possibilities to train or learn on a “map” with a certain list of “basic” work and as well as optional tasks, where the pupils are to be able to fulfill the tasks in teams and with the help of a learning video. We choose a certain unit in maths (“the circle”). To make additional learning and tasks attractive, the usage of “stars” and the potential to re-do tests and work was additionally given. Based upon seamless learning considerations and our existing requirements for learning and teaching settings, we decided to use internet-based videos as the main component in teaching. According to McGarr (2009) video podcasts or vodcasts are video files in a digital format, which are distributed through the Internet using RSS-feeds. Literature often distinguishes between receptive viewing of video podcasts (e.g., entire lecture recordings), which happens in a mainly passive manner, and the watching of worked examples video podcasts, which provide audio-visual explanations of a specific procedural problem (Kay & Kletskin, 2012). Observation of the didactical approach using worked-out examples within maths education demonstrated clearly how our videos should be developed. The benefits of learning with written worked examples, often in the field of mathematic instruction, are well established and are often summarized by the term “worked example effect” (Carroll, 1994). Written worked examples provide a step-by-step solution of a specific problem and it has been shown that especially weaker students or students with no or low problem specific knowledge benefit by working with it (Caroll, 1994). Unfortunately research studies about the use of worked example videos in undergraduate mathematic instruction are very limited (Kay & Edwards, 2012; Kay, 2012). Nevertheless there are at least some results, which indicate that this research field should be investigated more in depth. For example Boster et al. (2007) pointed out that middle school students who watched mathematical video podcasts performed significantly better in a post-test than those students who did not. Furthermore Kay and Edwards (2012) reported that the learning performance of math students (between 11 and 13 years old) who watched worked example videos increased significantly. Additionally students stated that they liked working with those video podcasts and considered them quite helpful (Kay & Edwards, 2012).
Building on the design-based research approach we discussed our plans with teachers as well as researchers, produced videos and materials, tested them with a small group of peers, and re-visited them if needed. The following is the evaluation of the field experiences.

**Research methodology**

**Question and hypotheses**

The aim of this study is to evaluate the effects of an open education approach applied in a fifth grade maths class supported by the usage of worked example videos. Accordingly the overall research question is:

Q: Is it possible to initiate seamless learning within open education approach in Maths education, while achieving at least the same learning performance of traditional approaches?

On the basis of this research question, six hypotheses have been formed:

**H1:** The average learning performance of the experimental group is not lower than the learning performance achieved by the control group.

**H2:** The participants of the experimental group like the open education approach and feel motivated.

Previous studies have shown that the learning performance of students learning in an “open educational” setting is lower than in traditional settings (Boekaerts, 1999; Greene & Land, 2000). However some other work suggest, that learning with problem based examples and problem based video podcasts can influence learner’s achievement in a positive way (Kay & Edwards, 2012; Kay & Kletskin, 2012; Kay, 2014).

**H3:** The provided worked example videos are used steadily during class by the participants of the experimental group.

**H4:** The participants of the experimental group also use the provided worked example videos outside the math class.

In several studies participants reported, that they had enjoyed learning with worked example videos (Kay & Edwards, 2012; Kay & Kletskin, 2012; Kay, 2014; Copley, 2007; Dupagne et al., 2009). Furthermore previous work has shown a highly usage of educational video podcasts outside of school and university (Heilesen, 2010; Copley, 2007; Hill & Nelson, 2011).

**H5:** Not dealing with learning contents covered by worked example videos during the working phase (in or outside the class) has a negative influence on the post-test.

**H6:** Continuous feedback from the teacher during the working phase – via incentives and comments – motivates students to correct their mistakes

**Participants**

For this study, all fifth grade pupils of an Austrian secondary school in Graz were recruited providing $N = 85$ participants. Of these, 8 were females and 77 were males. The average age was about 10.6 years ($SD = 0.31$).

**Study design**

The study took place in a secondary school in Graz and involved students and teachers of four fifth grade math classes over a two weeks period (see Table 1). The same teacher instructed two of these classes; therefore three different teachers (all female) were part of this study. As shown in Figure 1, the same teacher (Teacher A) was used for the control group. The experimental group was named the E-group and the control group was named C-group. The remaining two classes served as further control groups (FC1-group and FC2-group).
One essential fact is that this field study took place in the daily maths class of the participants and not in an artificial environment. Therefore it was not possible to control the interaction between the experimental group and the control groups. Hence, the regular teachers taught all groups of pupils (as shown in Figure 2). Moreover, the examiner of this research study only appeared as a silent observer in the different classes during the whole experimental phase.

The independent variable in this study is the instructional setting, which was applied in the different classes. Whereas in the experimental group (E-group) an innovative open education approach (see later on for detail information) was used, the control groups (C, FC1 and FC2) experienced a traditional face-to-face mathematics instruction. We applied a typical pretest and post-test 2 x 2 design (type of instructional setting x pretest and post-test) to compare the different groups. Furthermore the learning performance as the dependent variable was measured by comparing the pretest and post-test results of the participants (learning performance = score in post-test – score in pretest) (Holzinger et al., 2009).

Experimental setting

As shown in Figure 3, the present study started on the 29th of January 2014, when all participants (of all four groups) completed the pretest. Additionally, the participants of the E-group were introduced to the experiment. The working phase (experimental phase) took place from the 3rd of February till the 12th of February and included 8 regular maths lessons (50 minutes) in school for each group. Finally on the 13th of February all participants completed this study by doing the post-test.
Boundary conditions for the experimental group

The boundary conditions applied to the E-group were:

- **No teacher-centred teaching at all:** The open education approach was student-centred through the whole working phase. The teacher was only allowed to answer specific students' questions, but only if the pupils themselves initiated these questions.

- **Worked example videos and further learning material:** Overall 21 worked example videos were provided and a pool of 56 exercises, which were accessible for students by a course within the learning management system Moodle. In this context, it is important to mention that only 12 of these exercises (and the corresponding videos) had to be done in a specific order, called the “basic exercises.” These basic exercises had to be done beforehand; only then were pupils allowed to do the other exercises and to watch the corresponding videos. In contrast to the basic exercises, students could chose autonomously which exercises they wanted to do (not all of them needed to be done) and in which order. Finally, consistently pursuing the open education approach, students were also allowed to use other material, for example their textbook, to do their exercises if they did not want to use the provided worked example videos.

- **Working in teams:** The pupils were divided into eight teams, as heterogeneously as possible (three students per team) by their teacher (Teacher A). According to Cohen (1994) working in heterogeneous teams is beneficial, especially for weaker students, due to the fact that good students do not suffer under these circumstances. Finally, pupils were not only allowed to work with students from other teams, but also alone too.

- **Incentives and Feedback mode (“stars”):** After pupils finished their exercises, they handed them in and received a written feedback (short statements, if they had made any errors) from their teacher in the next lesson. If everything was done correctly, the pupils were rewarded with “stars.” It is important to note that the students received a work-plan from their teacher at the beginning of the work phase. This explained how many stars could be accrued for the completion of which exercise (at least 1 star, at most 3 stars per exercise, see 3.7). Another crucial factor of the incentive mode was that the stars were added up per team. In short, every pupil was just as good as his/her team. The hidden agenda of this mode was that a lightly competitive environment would emerge between the different teams, which was intended to not only be “fun” for the pupils but also to motivate them to work closely together within their teams. Moreover we emphasized that it would also motivate pupils if they could correct their mistakes to receive stars for it at the end. Finally it should be mentioned that this feedback mode was only applied to the experimental group. The students of the control groups only received verbal feedback from their teachers during their math lessons.

Course contents

**Work plan**

The work plan (Figure 4) provided an overview of all possible exercises students could do on a voluntarily basis during the working phase. These exercises were divided into seven different parts, which were named:

- **Basic exercises (12 exercises):** These exercises were the only ones that had to be done in the given order and within the predefined teams.

- **The training ground (15 exercises):** The training ground provided all different kinds of exercises.

- **The drawing meadow (7 exercises):** The “drawing meadow” included just exercises where students had to draw something (e.g., a chord, a circle pattern).

- **The quiz triangle (6 exercises):** The “quiz triangle” provided six exercises that mainly dealt with theoretical knowledge (e.g., the definition of a tangent). These exercises were mostly multiple-choice questions.

- **The senior ring (5 exercises):** The five exercises from the “senior ring” were relatively difficult, so these exercises were rewarded with 3 stars each.

- **The crafting corner (1 exercise):** This was just one exercise, where students could work with scissors and paper.

- **Homework (9 exercises):** The homework sector included 9 exercises that students could do at home or simply outside the class, but the exercises were not mandatory. However the intention was these exercises would support the open education approach.
Figure 4 shows that every exercise of the 56 was marked with a specific token (e.g., “G1” or “Z4”), so that students could easily find the corresponding worksheets or the worked example videos according to the exercise in Moodle. Furthermore, the number of stars each exercise was worth was easily visible.

**Worksheets**

For each of the 56 exercises on the work plan an additional worksheet was provided in Moodle. Every worksheet was marked with the appropriate token (e.g., “G1”) – according to the exercise on the work plan. Additionally, the related worked example video was clearly visible on the sheet. The number of stars (incentives) was indicated at the bottom of the worksheet. Figure 5 shows an example worksheet.
Worked example videos

Overall, 21 worked example videos were developed. These videos did not contain any further information than that provided by the students’ textbook (in other words: the students of the E-group did not have any advantage compared to the students of the control groups).

The videos were filmed with a simple digital camera and afterwards edited with the open film editing software Lightworks (www.lkws.com). The average development time for one worked example video was about 180 minutes.

<table>
<thead>
<tr>
<th>Table 2. Worked example videos</th>
<th>Videos (amount)</th>
<th>Duration (min – max)</th>
<th>Mean (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basic exercises</td>
<td>12</td>
<td>159 s – 373 s</td>
<td>258 s (76 s)</td>
</tr>
<tr>
<td>The training ground</td>
<td>7</td>
<td>74 s – 130 s</td>
<td>100 s (18 s)</td>
</tr>
<tr>
<td>The senior ring</td>
<td>1</td>
<td>84 s</td>
<td>84 s (0 s)</td>
</tr>
<tr>
<td>Homework</td>
<td>1</td>
<td>93 s</td>
<td>93 s (0 s)</td>
</tr>
</tbody>
</table>

We tried to keep every video as short as possible to address issues of limited attention span (Kay & Kletskin, 2012). The duration of the videos varied between 74 s (1:14) and 373 s (6:13). On average the videos last 189 s (3:09) with a standard deviation of 98 s (1:38). See Table 2 more for detailed information. Figure 6 shows some screenshots of the videos.

Pre- and posttests

Identical pre-tests and post-tests were used in this research study. For each test, students had a time contingent of 20 minutes and the test combined two different kinds of exercises:
- 12 single choice questions (Figure 7)
- 4 practical exercises, where students had to draw something (Figure 8)
Q6: What is shown in the figure on the right?

- [ ] Diameter
- [ ] Chord
- [ ] Tangent
- [ ] Radius

*Figure 7. One typical single choice question in the pre-post-test*

EX 1: Draw the **longest chord** of this circle through the Point P!  
*Label it with \( s_1 \)!*

Draw the **shortest chord** of this circle through the Point P!  
*Label it with \( s_2 \)!*

*Figure 8. One practical exercise in the pret-post-test*

**Moodle course**

A Moodle (www.moodle.org) course was provided for the E-group, so that students could easily access all learning resources such as worksheets and worked example videos – not only in school, but also externally.

**Control sheet for students’ working progress**

A control sheet was provided for the teacher of the E-Group to document every student’s working progress for each day of the experimental working phase. The teacher had to mark every exercise a student did in this sheet and whether the student did it correctly or not. In addition, the teacher had to flag each exercise that was not initially correct, but was subsequently corrected by the student after receiving feedback from the teacher.

**Students’ survey**

The students of the E-group had to fill in a 17 item, five-point Likert-type scale survey, assessing the pupils’ attitude concerning the worked example videos. A translated and slightly adopted version of the survey of Kay and Edwards (2012) was used for this, because they created this survey for similar purposes for students of the same age and the internal reliability of the entire scale is adequate (0.84).
Collected data

During the entire experiment the following data was collected:

- Learning performance (pre- and posttest)
- Video views
- Working progress (measured in “stars”)
- Students’ attitude towards worked example videos (survey)
- Student’s interview
- After the post-test, we interviewed the students of the E-group in groups of six and elicited their opinion concerning the entire experimental learning style approach.
- Teacher’s interview
- Observations during the experiment

Results

H1: The average learning performance of the experimental group (E-group) is not lower than the learning performance achieved by the control group (C-group)

An identical pretest and post-test was used to measure learning performance of the participants. The calculated learning performance is calculated as the difference between the post-test and pretest results (e.g., Holzinger et al., 2009). As can be seen in Table 3 and in Figure 9, the E-group and C-group – which were taught by the same teacher – nearly scored the same points in the pretest (split-half reliability coefficient with Spearman-Brown-Correction $r = .67$ - most results were near zero), but differ enormously in the results of the post-test (reliability $r = .77$) – the E-group performed much better. Moreover, the E-group also scored much better in the post-test than the other two control groups (FC1 and FC2). In total, a maximum of 22 points was achievable.

**Table 3. Results of the pre-post-test**

<table>
<thead>
<tr>
<th></th>
<th>E</th>
<th>C</th>
<th>FC1</th>
<th>FC2</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pretest</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean ($M$)</td>
<td>1.08</td>
<td>1.00</td>
<td>4.00</td>
<td>2.15</td>
</tr>
<tr>
<td>Standard deviation ($SD$)</td>
<td>1.32</td>
<td>1.25</td>
<td>1.74</td>
<td>1.70</td>
</tr>
<tr>
<td><strong>Post-test</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean ($M$)</td>
<td>17.21</td>
<td>14.74</td>
<td>14.24</td>
<td>12.31</td>
</tr>
<tr>
<td>Standard deviation ($SD$)</td>
<td>3.52</td>
<td>3.95</td>
<td>3.56</td>
<td>4.37</td>
</tr>
</tbody>
</table>

**Figure 9. Learning performance of all 4 groups**
The average learning performance of the E-group is $M = 16.13$ ($SD = 3.55$) and the average learning performance of the C-group is $M = 13.74$ ($SD = 3.80$). Hence the results show that the E-group’s learning performance is better than the performance of the C-group. Moreover a univariate analysis of variance (ANOVA) yielded a significant effect of the learning style approach ($F(1, 45) = 4.94; p = 0.0313$) within the 5%-level. The effect size is $r = 0.31$ and Cohen’s $d = 1.13$.

**H3: The worked example videos were used steadily during class by the participants of the experimental group**

![Figure 10. Video views on each day of the experimental working phase](image)

<table>
<thead>
<tr>
<th>Item</th>
<th>$M$</th>
<th>$SD$</th>
<th>Agree (%)</th>
<th>Disagree (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Overall, I liked using the clips.</td>
<td>4.63</td>
<td>0.56</td>
<td>96%</td>
<td>0%</td>
</tr>
<tr>
<td>2. The clips were easy to follow.</td>
<td>4.42</td>
<td>0.64</td>
<td>92%</td>
<td>0%</td>
</tr>
<tr>
<td>3. The problem was explained well.</td>
<td>4.42</td>
<td>0.57</td>
<td>96%</td>
<td>0%</td>
</tr>
<tr>
<td>4. All steps were explained clearly.</td>
<td>4.29</td>
<td>0.53</td>
<td>96%</td>
<td>0%</td>
</tr>
<tr>
<td>5. I was confused by some steps.</td>
<td>1.88</td>
<td>0.67</td>
<td>0%</td>
<td>83%</td>
</tr>
<tr>
<td>6. The videos helped me to understand.</td>
<td>4.67</td>
<td>0.47</td>
<td>100%</td>
<td>0%</td>
</tr>
<tr>
<td>7. Writing in the clips was easy to read.</td>
<td>4.88</td>
<td>0.47</td>
<td>100%</td>
<td>0%</td>
</tr>
<tr>
<td>8. Diagrams helped me understand.</td>
<td>5.00</td>
<td>0.00</td>
<td>100%</td>
<td>0%</td>
</tr>
<tr>
<td>9. Good tips were provided.</td>
<td>3.71</td>
<td>0.79</td>
<td>67%</td>
<td>8%</td>
</tr>
<tr>
<td>10. The clips were too long.</td>
<td>2.25</td>
<td>0.97</td>
<td>17%</td>
<td>71%</td>
</tr>
<tr>
<td>11. The clips went too fast for me.</td>
<td>1.83</td>
<td>0.80</td>
<td>4%</td>
<td>83%</td>
</tr>
<tr>
<td>12. I used the pause feature to stop the clips sometimes.</td>
<td>2.75</td>
<td>1.13</td>
<td>29%</td>
<td>42%</td>
</tr>
<tr>
<td>13. The videos were boring.</td>
<td>2.17</td>
<td>0.99</td>
<td>13%</td>
<td>67%</td>
</tr>
<tr>
<td>14. I liked using videos better than using the textbook.</td>
<td>5.00</td>
<td>0.00</td>
<td>100%</td>
<td>0%</td>
</tr>
<tr>
<td>15. These clips were helpful for homework.</td>
<td>4.63</td>
<td>0.48</td>
<td>100%</td>
<td>0%</td>
</tr>
<tr>
<td>16. I would use these clips to review for assignments.</td>
<td>4.46</td>
<td>0.64</td>
<td>92%</td>
<td>0%</td>
</tr>
<tr>
<td>17. These clips would be helpful for extra help.</td>
<td>3.21</td>
<td>1.15</td>
<td>46%</td>
<td>29%</td>
</tr>
</tbody>
</table>

**Note.** Agree: Both, Agree (4) and Strongly Agree (5). Disagree: Both, Disagree (2) and Strongly Disagree (1).

Figure 10 suggests steady usage of the video podcasts during the experimental working phase, especially in the first four days of experimental working phase. This makes sense, since the students had no relevant prior knowledge concerning “the circle” according to the pretest results.

Certainly, the numbers in Figure 10 also include views outside the maths class and with different (mobile) digital devices. However the results of students’ interviews and the student’s survey show that the worked example videos
provided were often and willingly used during class by students. For example 96 % of the students said in the survey that they liked working with the provided video podcasts. All students reported that they preferred working with the video podcasts instead working with the textbook (see Table 4). Additionally, all of the students thought that the videos helped them to understand the learning content. All in all, we counted 17 positive comments in the students’ interview concerning the worked example videos; for example, some mentioned that they enjoyed working with the videos. One student explained that he liked the possibility to pause and rewind the clip whenever he wanted to. One participant argued that he did not need the video clip and another complained about the intro, which was in the beginning of every clip and in his opinion too long (ca. 30 s).

**H4: The participants of the experimental group also use the provided worked example videos outside the math class**

In the students’ survey (Table 4) all of the students stated that the provided worked example videos were helpful for doing their homework, e.g., outside the classroom. They also rated this statement with 4.63 (whereby 1 means: “No, I definitely do not agree” and 5 means: “Yes, I fully agree”). Additionally, some students explicitly mentioned their usage of the videos outside the class during the interview.

**H5: Not dealing with learning content covered by worked example videos during the working phase (in or outside the class) has a negative influence on dealing with these contents during the post-test**

To validate this hypothesis, we included two exercises in our post-test (these exercises were already in the pretest since they were identical), which refer to two specific exercises (and videos) during the experimental working phase. Exercise 1 from the pre/post-test refers to exercise “Ü9” from the work plan, and exercise 3 from the pre/post-test refers to exercise “P5” from the work plan.

According to the work progress control sheet for every student, exactly 13 students did the exercise “Ü9” during the working phase and 11 did not. As shown in Table 5, the 13 students who did exercise “Ü9” scored in the according post-test exercise 1 in average \( M = 1.85 \) points (\( SD = 0.38 \)), while the 11 students who did not do “Ü9” only scored \( M = 1.09 \) points (\( SD = 0.70 \)).

If we compare the average score of exercise 3 in the post-test from the 14 students who did “P5” during the working phase (\( M = 1.79; \ SD = 0.58 \)) with those 10 who did not (\( M = 0.50; \ SD = 0.85 \)), the result is even more impressive (\( F(1,22) = 19.54; \ p < 0.001 \)).

Table 5. Post-test results of exercise 1 and 3 dependent on whether the corresponding exercises (Ü9, P5) were done during the experimental working phase

<table>
<thead>
<tr>
<th>Post-test result of exercise 1</th>
<th>Completed “Ü9”</th>
<th>Completed “P5”</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Yes (( n = 13 ))</td>
<td>No (( n = 11 ))</td>
</tr>
<tr>
<td>Mean (( M ))</td>
<td>1.85</td>
<td>1.09</td>
</tr>
<tr>
<td>Standard deviation (( SD ))</td>
<td>0.38</td>
<td>0.70</td>
</tr>
</tbody>
</table>

**H6: Continuous feedback from the teacher during the working phase – via incentives and comments – motivated students to correct their mistakes**

An evaluation of the students’ control sheet of their individual working progress showed that overall 396 exercises needed to be corrected by the teacher during the working phase and that in fact 299 of them were corrected again by the students. This is equal to a rate of 75.5 %, which is surprisingly high regarding the circumstance that students were not forced to correct any of them. As can be seen in Table 6, stars seemed to play a big role in students correcting their mistakes. While “only” 68.2 % of the exercises rewarded with 1 star were corrected, 85.4 % of the
difficult “3-star-exercises” were corrected. Furthermore, many students mentioned in the interview that they liked “collecting stars” and that they felt more motivated to do their exercises (11 statements).

Table 6. Rate of the corrected exercises dependent on their value (stars)

<table>
<thead>
<tr>
<th>Value</th>
<th>1 Star</th>
<th>2 Stars</th>
<th>3 Stars</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exercises Needed to be corrected</td>
<td>157</td>
<td>157</td>
<td>82</td>
<td>396</td>
</tr>
<tr>
<td>Were corrected</td>
<td>107</td>
<td>122</td>
<td>70</td>
<td>299</td>
</tr>
<tr>
<td>Rate</td>
<td>68.2%</td>
<td>77.7%</td>
<td>85.4%</td>
<td>75.5%</td>
</tr>
</tbody>
</table>

**H2: The participants of the experimental group liked the open education approach and felt motivated**

As already discussed (H3 and H4) the participants liked the worked example videos. In summary, 76 statements in the interviews from 19 different students were counted concerning how much they liked the whole setting as such. In Figure 11 the cumulative progress of the incentives (stars) every team had collected during the whole experimental working phase is shown. As can be seen, the progress was very similar in each team. Considering this, it can be stated that the open education approach was very motivating for most of the students. Finally, the teacher of the E-group (who was also the teacher for the C-Group) stated in the interview that in her opinion the students of the E-group were much more motivated during the whole working phase than the C-group’s students in the traditional setting.

![Figure 11. Cumulative progress of the incentives (stars) of every team](image)

**Discussion**

**Learning result**

In H1 it has been shown that the open education approach – which supported self-regulated learning, learning with worked example videos and learning in teams – leads to a significantly better learning result than the traditional method. The experimental group (E-group) was not only better than the control group (C-group), which was instructed by the same teacher, but was also – even much better than the other two control groups (FC1-group and FC2-group), which were taught by different teachers. Furthermore it has been shown in H2 that students of the E-group also liked working in this entire experimental setting much more than other students.
Worked example videos

H3 and H4 demonstrated that students liked working with the provided worked example videos not only in school but also at home. One student for example mentioned that he often used typical video features – like pausing and rewinding. These findings correspond with previous experiments in middle school (Kay & Edwards, 2012) and in higher education (e.g., Copley, 2007; Hill & Nelson, 2011; Kay, 2012).

H5 pointed out that there is really a correlation between watching worked example videos and the learning result. This was proven by the fact that those students, who did not watch two specific videos during the experimental phase, did significantly worse in the corresponding exercises in the post-test than those students who did watch the videos. Kay and Kletskin (2012) got similar results: Watching worked example videos can lead to better learning performance.

Incentives, feedback and working in teams

A high level of motivation is probably the sin qua non of a good learning success (Ebner & Holzinger, 2007). Keeping this in mind, we tried to figure out how to motivate students in a way which will be (a) age-appropriate, (b) beneficial for team work and (c) kind of “fun” for children in the age-group around 10.

As shown in H6 and H2, the proposed approach of using stars for rewarding students’ efforts combined with the aspect that the stars were added up per team seems to fulfil the three named requirements. H6 proved for example the fact that students were more motivated to correct their mistakes when they were rewarded with more stars for their exercises.

In addition to this, H2 indicates that most of the students liked working in teams – but they particularly valued the possibility that they always were allowed to choose with whom to work with, even across teams or alone. Moreover, the students stated in the interviews that they often worked very closely in teams and that the “better” team members helped the “weaker” ones, so that they could earn a high amount of stars. Finally, the teacher of the E-group said in the interview that in her opinion this “star-collecting” modus was very much age-appropriate since children of this age often play games (e.g., computer games) where they have to collect objects like stars or mushrooms to succeed.

Limitations

There are, however, a few limitations within our study. First there was no random selection of the participants for the experimental group and the control groups since we had to assign whole classes for our groups. Secondly, not only the experimental group but also the direct control group (C-group) only included male participants. In some previous research, female students outperformed male students by learning with video podcasts (e.g., Bolliger et al., 2010), while in other studies no correlation between gender and learning performance by the usage of video podcasts was observed (e.g., Chester et al., 2011; Kay & Kletskin, 2012). Nevertheless, gender influences might be possible for the used incentive systems and the sporty metaphor (“start”/“goal,” etc.).

A convincing number of studies have found that learners with poor self-regulated learning abilities tend to be less academically successful than learners with eminent SRL abilities (Zimmerman, 1989; Butler & Winne, 1995; Boekaerts, 1999). Besides the theoretically clear ambition to initiate and foster SRL competencies with an open education setting, studies show that open educational settings do not always fulfil the expectancies. Additionally, many studies have indicated that especially in e-learning and hypermedia learning environments students with poor SRL abilities mostly fail to achieve considerable learning performance (Hu & Gramling, 2008; Hadwin & Winne, 2001; Wang, 2011). Existing differences of SRL competencies as well as other influences may lead for example to undesirable differences in learning performance in open education settings.

Finally, with respect to the limited duration of this study, it may be possible that the so-called “novelty effect” enhanced the motivation of the participants of the experimental group per se and in further consequence also influenced their learning performance. As always in such field interventions, as in our case, the Pygmalion (Rosenthal) effect (Rosenthal & Jacobson, 1968) and the Hawthorn effect (McCarney et al., 2007) might be
considered as a potential influencer or enforcer of positive results. Thus the need of a long-term study should be considered for further research studies.

Conclusions

First and foremost, this study has clearly shown that an open education approach using worked example videos in maths can lead to a better learning performance than the traditional approach. Against the background of the age of the participants (about ten years), their limited experiences with self-regulated learning and limited experiences with usage of videos for learning, this result is even more impressive – and perhaps surprising.

The design of the teaching approach as an open learning setting, where the pupils were given a lot of freedom in the way they go through and use the learning materials (videos) on the one hand, and a well-prepared, entertaining, and helpful learning setting with incentives (stars) with relatively prompt feedback (each evening) on the other, obviously fits the pupils needs and pre-requisites.

Finally, the study has corroborated that teachers should provide open learning environments more often for their students in which they can experience self-regulated learning and develop self-regulated learning strategies. Thus the usage of worked example videos seems to look very promising not only for enhancing self-regulated learning environments, but even more so for the facilitation of seamless learning.

References


Authoring Robot-Assisted Instructional Materials for Improving Learning Performance and Motivation in EFL Classrooms

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ABSTRACT
Anthropomorphized robots are regarded as beneficial tools in education due to their capabilities of improving teaching effectiveness and learning motivation. Therefore, one major trend of research, known as Robot-Assisted Language Learning (RALL), is trying to develop robots to support teaching and learning English as a foreign language (EFL). As more practical studies on materials development have been called for, this paper details the methods of adopting the proposed RALL framework to design robot-assisted instructional materials for elementary students studying in an EFL national curriculum in Taiwan. Quantitative and qualitative experiments were conducted in this research to investigate the learning performance and motivation of the designed robot-assisted instructional materials. Two groups of participants from an elementary school in Taiwan enrolled in this experiment. The post-test results revealed that the experimental group outperformed the control group, particularly in terms of the improvement of listening and reading skills. Furthermore, the motivation survey of the instructional materials also showed that the experimental group’s learning motivation was positively influenced. Therefore, our research demonstrated that the instructional materials developed by our RALL framework provide a great opportunity to foster elementary students’ English language learning.

Keywords
Robot-assisted language learning, Learning performance, Learning motivation, ARCS

Introduction
Anthropomorphized robots are found beneficial when they are implemented in education due to their advantages of executing verbal and nonverbal communication with teachers or students in classrooms (Johnson, 2003). For example, some research studies have used autonomous humanoid robots in English classrooms to play the role of native speakers that are able to carry on conversations with pupils in natural language (Lee et al., 2011; Hyun et al., 2008; Movellan et al., 2009; Park et al., 2011).

Research studies have confirmed that this type of interaction between robots and humans not only improves teaching effectiveness but also learning motivation because students are less anxious and more cheerful (Papert, 1993). Therefore, more and more applications of robotic technology are now trying to develop activities that can be helpful for teaching and learning English as a foreign language (EFL). This current trend of using robotics to assist language instruction is now known as Robot-Assisted Language Learning (RALL) (Han, 2012).

Despite the great benefits of using robots in language teaching and learning, the current application may be limited because of the two major reasons. First, autonomous robots have complex artificial intelligence and are so expensive that normally schools cannot afford them. Moreover, the interaction scenarios between pupils and robots must be pre-programmed by robotics developers, so educators who are not robotics professionals may find it difficult to design or alter the interaction scenarios. Therefore, an alternative to solving the above problems is to buy robots with simple autonomous functions and remote controlled body movements from the supermarkets, or toyshops. These robots are mostly developed in a small size and at a low-cost. Meanwhile, they could be simply controlled by instructors to perform pedagogical missions and teaching materials in the classroom activities. This type of robots is often used as an instructional tool for facilitating learners’ engagement and oral interaction. Research has found that interacting with a tangible robot increased more engagement than with a video (Xie, Antle, & Motamedi, 2008). For instance, ROBOSAPIEN, a low-cost remote controlled robot that can be purchased from a toyshop, has been used to
be an instructional tool for EFL class at an elementary school (Chang et al., 2010a; Chang et al., 2010b; You et al., 2006). Although there was a breakthrough in terms of reducing the cost of using robots in language teaching and learning, those commercial robots were still not well developed into education because normally instructors had to take much time and effort to interlink robots with instructional materials and classroom activities. In order to expand robot-assisted language teaching, Han (2012) suggested that the system frameworks of RALL combine robot hardware, robot applications and visual instructional contents and help instructors easily design their robot-assisted instruction. Furthermore, the design of the system frameworks should take the language learning goals into account.

In our previous research studies, a RALL system framework has been implemented. The developed framework provides an authoring tool for instructors to script teaching materials that can easily add external multimedia resources as well as to script presentations of anthropomorphized robots. Moreover, a material display system can also be found in the framework. Therefore, the present study is, first, to provide a practical study of creating an EFL course using the framework to design robot-assisted instructional materials. Then, it shows the empirical evidence of the designed instructional materials based on students’ learning outcomes. Finally, it presents the impact of students’ learning motivation because motivation is a critical element to sustain students’ attention and engagement in the learning process.

In our current study, two groups of the fifth-grade elementary students were targeted to make the comparison. The experimental group used the robot-assisted instructional materials, whereas the second group participated in a traditional curriculum that used multimedia instructional materials without robots. Our results showed that the students who used the robot-assisted materials had better learning performance than those in the control group. Regarding the results of learning motivation survey, our participants in the experimental group were motivated by the designed instructional materials.

**Related works**

**Robot-assisted language learning**

Research studies have applied educational robots in language education. In second language (L2) education, it was noticed that it can be effective if learners directly interact with a native speaker in a class. Han (2012) believed that autonomous robots embedded voice recognition technology can perform the role of native speakers to interact with learners. The examples are IROBIQ (Hyun et al., 2008), ROBOSEM (Park et al., 2011), and so on. An autonomous robot has features such as screen, image recognition via camera, voice recognition via microphone, and various sensors. Furthermore, robots were embedded complex autonomous functions. Studies adopted these robots in language education have shown positive impact on pupils’ story building, vocabulary, and word recognition (Lee et al., 2011). Another type is tele-operated robot that a teacher operates and controls a robot to provide educational services remotely. Wearable robots are similar to this type. A teacher wears a set of sensors and controllers like a harness to trigger a robot for mimicking the teacher’s movements. However, as mentioned, these autonomous and tele-operated robots used in the research were expensive or were only developed in some primary laboratories that were not sold in markets. Thus, English classes in Taiwan normally do not have such implementation.

An alternative to acquiring robots in a class is to employ the ones with simple autonomous functions and even some of them are from toyshops. Some low-cost robot development kits such as Lego mindstorms NXT and Bioloid have been applied in education. Chen (2011) proposed a learning system that integrated with books, multimedia content, and a Bioloid humanoid robot for improving elementary students’ English learning. As students read English in a book, they were also supported by the scaffolding of multimedia resources in tablet PC and social interaction with a humanoid robot. The five fifth-graders enrolled in Chen’s field experiment and the collected data including video recording and interviews showed that those students engaged in the learning, and the learning system motivated students. Compared with Chen’s research, our research plans to incorporate a humanoid robot with instructional materials and provides empirical evidence to find robotics potential for fostering classroom teaching.

You et al. (2006) adopted ROBOSAPIEN which is a low-cost toy humanoid robot to perform the role of a teacher assistant in English class. An assistant in a corner of the classroom watched the teacher’s signals and remotely controlled the robot to perform motions to link with classroom activities. Elementary students enrolled in this research, and the experiment reported that the teacher and students had positive comments about applying the
humanoid robot in English learning activities (Chang et al., 2010a). Compared with this research, our RALL framework supports teachers to design multimedia teaching content and robot’s performance together. By using this method, we do not have to deploy an assistant in the classroom to control the robot remotely.

**Student motivation and second language achievement**

Motivation is a critical element to sustain students’ attention and engagement in learning. It also plays an important role in learning an L2, in particular in terms of learning the one at school as an additional foreign language which is not normally used in students’ daily lives. Thus, two types of motivation, language learning motivation and classroom learning motivation, have been identified in Gardner’s L2 acquisition research (Gardner, 1985, 2007). The former refers to an individual’s level of willingness to communicate with others by using an L2 with more internal or personal drive. The latter, however, refers to the motivation derived from the influence of the classroom settings. More often than not, external factors in EFL classroom environment including the instructor, teaching materials, teaching strategies and facilities will have major impacts on learners’ classroom motivation.

Keller (1987) has developed an ARCS model to assist educators in a systematic process to analyze a student’s motivation after he/she learned the instructional material (Keller, 1987; Keller, 2008). The ARCS model provides four scales—attention, relevance, confidence, and satisfaction—to measure an individual’s level of learning motivation influenced by the instructional materials. The first scale, attention, emphasizes that an instructional material in a class must gain and sustain a learner’s curiosity, enthusiasm and interest. The second scale, relevance, is related to how well a connection is made between instructional content and a student’s learning needs and goal. The third scale, confidence, is related to how successful a student is in the learning process. The final scale, satisfaction, is related to the student’s positive feelings about the learning experiences. The Instructional Materials Motivation Survey (IMMS) is an instrument derived from the ARCS model to assess learners’ motivation towards the instructional material (Bolliger et al., 2010; Huang et al., 2006; Huang et al., 2010). In our research, IMMS was selected to measure the change of students’ motivation before and after learning robot-assisted instructional materials.

**Method**

The primary objective of the current study was to show the impact on learners’ learning performance and motivation while learning robot-assisted multimedia instructional materials in an English classroom.

**RALL framework development**

The RALL framework in our research is consisted of a programmable humanoid robot, an instructional material editing tool and a material displaying system. The programmable robot, Bioloid, is a commercial development toolkit that composes a main controller and several pieces of motors, sensors, and wireless communication modules. The twenty-six types of robots, from spider to humanoid, can be built. In this research, we built the robot in humanoid type. Using the form of a human being rather than other appearances for the robot can be more suitable to the learning environment in schools because such an outlook can make students associate the robot with the substitute of their real teacher, i.e., their teacher’s assistant.

Regarding the design of the robot’s motions, the Bioloid development kit supports a visual editor to easily develop the customized motions. For the majority of commercial robots in the market, a major limitation is that robots are not equipped with any facial expression module. Therefore, our robot is not capable of responding to learners with facial emotions.

In order to design a robot to perform an educational role and interact with learners, the robot should be interlinked with the instructional contents. However, as teachers who are not computer professionals might not be capable of designing the instructional materials that integrate with robots, our framework supports a visual material editing tool allowing teachers to edit robot-based instructional materials easily and intuitively. This visual editing tool contains a visual editor and the XML-based scripting language. The visual editor provides a set of graphical user interfaces for
teachers to easily create teaching materials and deploy necessary multimedia resources such as pictures, video clips, or audio files on the materials. Furthermore, teachers can use this editor to select robot motion patterns and integrate the presentations of the robot with their own materials.

The XML-based scripting language in our research is a meta-language to link the editor with the robot’s presentations. The design of the markup language refers to the segmenting principle. Mayer (2005) stated that a lesson in a class can be divided into bite-sized manageable segments to reduce learners’ cognition loads. The instructor combines a set of multimedia resources into a segment, and further links a sequence of segments to a given lesson. Therefore, our scripting language is based on a three-layered hierarchical tagging structure. The three levels are lesson level, segment level, and tutor level. A lesson organizes a set of segments. In the lesson level, a teacher can announce overall lesson information and declare the starting point of its segments. A segment represents the teaching context consisting of the presenting schedule of humanoid robots and multimedia resources. In the tutor level, teachers can script the presentation details of a robot, including its motions and oral/textual speeches. The following is a sample of tutor script. In this script (see Figure 1), the humanoid robot presents a motion to wave left hand and a speech, “How are you?” encoded in a greeting.wav audio file. One limitation is that a teacher has to record all necessary speech beforehand because Bioloid does not have a built-in programmable speech module.

```
<Tutor TutorID="T001">
    <Actor>Bioloid_Robot</Actor>
    <Motion>WavingHand</Motion>
    <Speech>greeting.wav</Speech>
</Tutor>
```

Figure 1. A sample of tutor script

A segment is like a page of teaching content that contains a theme with several necessary multimedia resources. Furthermore, a segment contains an order of tutor scripts for the presenting schedule of the robot’s motions. The following is an example of segment script (see Figure 2). In this example, the segment displays a .jpg file to be the theme and simultaneously to trigger two robot motions (i.e., T001 and T002), “clapping” and “dancing,” sequentially. All segments have to be combined into a lesson script. Therefore, this lesson script must specify an initial segment and the order of the other segments.

```
<Segment SegmentID="S001">
    <Theme>1.jpg</Theme>
    <Tutor>T001</Tutor>
    <Tutor>T002</Tutor>
</Segment>
```

Figure 2. A sample of segment script
Figure 3 shows the instructional material editing tool for teachers to create and modify three types of scripts. The left area of the main window is a canvas to display the current lesson structure in a graph consisting of segments. Each segment is depicted as a rectangular block. The link between the two segments is represented as a solid line. Teachers can insert a new segment or remove an existing segment from the current lesson structure. Teachers can click and select a segment, segment AB4 shown in Figure 3, for example, and then configure details of this segment via the help of the editing tool. The segment configuration shown in Figure 3 provides GUI widgets to select an existing multimedia file (e.g., images and audio files) to present the theme of the segment. Similarly, this configuration also provides GUI widgets to select and link the current segment to its successive one.

![Material editing tool: (A) Main window (B) Robot motion list configuration](image)

The scripts edited by using the editing tool can be found in our display system. Figure 4 shows the main window of the display system. The left area of the display system is a canvas for displaying the visual multimedia curricular content. Students can read the teaching contents on the screen and see the robot’s motions and presentation. The right side of the main window can show the additional curricular explanation and robot textual speech.

![Main window of the display system](image)

Figure 5 shows our display system in a real learning setting at school. The necessary apparatus included a personal desktop or laptop computer, an overhead project and screen, a set of speaker, and the robot.
Participants

This study was conducted at an elementary school in Taiwan. The participants were two classes of the fifth-grade students and one school teacher. These students were divided into an experimental group and a control group. One class consisting of 25 students was labelled as the experimental group, while another class of 27 students was labelled as the control group. The researchers did not inform students of the special experimental lessons to be learned partly because the learning content was just like the regular classes at school and the learning activities could be controlled by the teacher, and partly because the reason of protecting from Hawthorne Effect in doing classroom research, meaning if the subjects are told to be involved in the experiment, they might behave differently, unnaturally, or positively. In a word, the experiment was integrated into the normal lessons to get the real research results.

The teacher had four-year teaching experience in English courses for fifth-grade and sixth-grade elementary students. Before the experiment, the teacher was invited to take a one-hour tutorial to learn the authoring tool and the display system. Then she was invited to design her own teaching content adopted in this evaluation. Furthermore, she was asked to administer instruction processes of both groups.

Curriculum design

The curriculum and teaching materials adopted in this experiment were based on a textbook approved by the Ministry of Education in Taiwan. Both groups of participants learned the same contents. In the experimental group, the contents were presented in the display system with a humanoid robot, while the ones used in the control group were only displayed through the display system without a robot. The teacher conducted the same teaching activities in both groups. The teacher engaged in all activities in the control group, but some activities in the experimental group were supported by the humanoid robot to share the teacher’s jobs such as leading certain activities and accompanying the students in their learning processes.

Four types of teaching activities were applied in both classrooms: storytelling, reading aloud, listening and acting, as well as questioning and answering. Storytelling activity intended to facilitate listening ability. In the traditional class like the control group, the teacher used English as native speakers do to present a story and performed funny movements to draw her learner’s attention. However, in the experimental group, the robot was assigned to be a main
performer to read the story and do actions (see Figure 6), and the teacher was only to be there to provide some explanations of the story, if necessary.

The reading aloud activity was based on audio-lingual method that aimed at increasing a learner’s verbal and pronunciation by reciting sentences. In the control group, the teacher would lead students to read words and sentences loudly. Furthermore, the teacher would also explain the structure of a sentence and vocabulary. That would facilitate an elementary learner to increase basic ability to write sentences correctly. In the experimental group, the robot shared with the teacher’s job to lead students to recite sentences. Then the teacher would have more opportunities to observe the students’ learning performance and correct pronunciation errors. Compared with the human teacher, the humanoid robot might ease students’ feelings of nervousness when they spoke in English.

The listening and acting activity was based on the total physical response method, emphasizing that learning a second language is similar to the process that an infant internalizes his/her native language by responding to parents’ speech with physical movements. In this experiment, the teacher in the control group asked students in English to respond with physical movements to commands such as “hands up,” “hands down,” and so on. The same activity was also conducted for the experimental group, but these commands were given by the robot. Then the teacher could observe the students’ physical movements and give correct feedback to help the students understand the robot’s commands if they responded wrong movements. Therefore, students would gain entertainment and still feel some sense of achievement when a humanoid robot corrected them rather than their human teacher.

The questioning-and-answering activity was used because of the impact of communicative approach which emphasizes the interaction as the major goal of increasing speaking ability. In Taiwan, in order to promote the student-talk rate in class, questioning-and-answering activity is rather common. In addition, the teacher designed classroom activities such as role playing, pair working, and game-based learning. For example, the robot in the experimental group was designed to be a native speaker of English to ask questions or to greet, such as “How are you?”,” “How old are you?”,” “What time is it?” and so on. Another instance of this activity was to use the robot to call a pair of students and then assign them conversational tasks. For example, the robot assigned one such as “Jack. When you forgot to take a pencil to the school, how can you ask Andy to borrow one?” Then the pair of students, Jack and Andy, must listen to the task carefully and perform a proper interaction with each other. The teacher played as a coach to encourage students to complete the role-play activity, and then she gave feedback. In the control group, the teacher conducted the same activity by herself.

**Instruments**

Our post-test adopted the formal examination paper designed by the school. The items were divided into four parts that could evaluate four types of language ability: listening, speaking, reading, and writing. The total score of the overall post-test was 100. In listening, there were 10 items and the maximum score of the listening category was 40. Students needed to listen to questions and check the correct words. In speaking, the teacher randomly showed three pictures for a student and the student had to orally explain the meaning of each picture. Then the teacher scored students’ responses based on their use of the sentence structure and grammar. The maximum score of the speaking
category was 12. There were 10 questions to evaluate reading comprehension. What students did in this section was to read an English sentence in a question format and chose a picture that was related to the reading question. The maximum score of the reading category was 30. There were 6 questions for evaluating writing. But because the fifth graders did not have the ability to write a complete sentence creatively, these questions used to test writing were the cloze-type test. The maximum score of the writing category was 18.

The instrument used for evaluating learning motivation was IMMS including four scales, Attention, Relevance, Confidence, and Satisfaction, along with a total of 29 questions shown in Table 1 below. Both groups of students responded to the questionnaire, and the final response rate was 100%.

<table>
<thead>
<tr>
<th>Item no.</th>
<th>Question</th>
<th>Scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>The learning materials can draw my attention.</td>
<td>Attention</td>
</tr>
<tr>
<td>2</td>
<td>The materials used in class are more difficult than I originally imagine.</td>
<td>Confidence</td>
</tr>
<tr>
<td>3</td>
<td>After learning from the materials, I have sense of achievement.</td>
<td>Satisfaction</td>
</tr>
<tr>
<td>4</td>
<td>I know very well that the learning materials are quite relevant to the English lessons I have learned.</td>
<td>Relevance</td>
</tr>
<tr>
<td>5</td>
<td>I do not know or remember what I have learned in class.</td>
<td>Confidence</td>
</tr>
<tr>
<td>6</td>
<td>The learning materials used in class make me engaged.</td>
<td>Attention</td>
</tr>
<tr>
<td>7</td>
<td>I think that the contents in the learning materials are worthwhile learning for students.</td>
<td>Relevance</td>
</tr>
<tr>
<td>8</td>
<td>The learning materials are very important to me when I learn English.</td>
<td>Relevance</td>
</tr>
<tr>
<td>9</td>
<td>It is very difficult for me to keep focusing on the learning materials because they are abstract.</td>
<td>Attention</td>
</tr>
<tr>
<td>10</td>
<td>I am confident because I feel that I can learn the lessons taught in class.</td>
<td>Confidence</td>
</tr>
<tr>
<td>11</td>
<td>I look forward to learning the forthcoming materials.</td>
<td>Satisfaction</td>
</tr>
<tr>
<td>12</td>
<td>The learning materials are quite boring and cannot draw my attention.</td>
<td>Attention</td>
</tr>
<tr>
<td>13</td>
<td>The learning materials used in class match with my interest.</td>
<td>Relevance</td>
</tr>
<tr>
<td>14</td>
<td>The learning materials help me pay attention in class.</td>
<td>Attention</td>
</tr>
<tr>
<td>15</td>
<td>The learning materials are too difficult for me.</td>
<td>Confidence</td>
</tr>
<tr>
<td>16</td>
<td>I am very curious about the learning materials.</td>
<td>Attention</td>
</tr>
<tr>
<td>17</td>
<td>I really enjoy learning the materials in this class.</td>
<td>Satisfaction</td>
</tr>
<tr>
<td>18</td>
<td>Sometimes the learning materials bore me.</td>
<td>Attention</td>
</tr>
<tr>
<td>19</td>
<td>Sometimes I am amazed at what I have learned from the learning materials; I learn more than I can imagine.</td>
<td>Attention</td>
</tr>
<tr>
<td>20</td>
<td>After attending the class for a period of time, I find myself more confident.</td>
<td>Confidence</td>
</tr>
<tr>
<td>21</td>
<td>In class, I feel I was motivated and I can have more sense of achievement.</td>
<td>Satisfaction</td>
</tr>
<tr>
<td>22</td>
<td>The ways the materials were taught in class help me focused.</td>
<td>Attention</td>
</tr>
<tr>
<td>23</td>
<td>The ways the materials were taught make me bored.</td>
<td>Attention</td>
</tr>
<tr>
<td>24</td>
<td>The learning materials and the teaching make me feel fun and interesting.</td>
<td>Attention</td>
</tr>
<tr>
<td>25</td>
<td>I feel good about the learning materials.</td>
<td>Satisfaction</td>
</tr>
<tr>
<td>26</td>
<td>The learning materials are useful for me.</td>
<td>Relevance</td>
</tr>
<tr>
<td>27</td>
<td>There are many places in the learning materials I do not understand.</td>
<td>Confidence</td>
</tr>
<tr>
<td>28</td>
<td>The learning materials help me learn in class and develop more confidence.</td>
<td>Confidence</td>
</tr>
<tr>
<td>29</td>
<td>I enjoy the materials chosen by my teacher so much.</td>
<td>Satisfaction</td>
</tr>
</tbody>
</table>

### Results

#### Learning outcomes

Table 2 presents post-test descriptive statistics. The two-tailed unequal variances t-test revealed that the experimental group had a significant difference at the 0.05 level in learning achievement, so the experimental group ($M = 89.80, SD = 11.899$) outperformed the control group ($M = 76.93, SD = 17.504$), where $t = 3.121, p = .003$.  

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Table 2. Post-test overall descriptive statistics

<table>
<thead>
<tr>
<th>Group</th>
<th>Mean</th>
<th>SD</th>
<th>t</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experimental group</td>
<td>89.80</td>
<td>11.899</td>
<td>3.121*</td>
</tr>
<tr>
<td>Control group</td>
<td>76.93</td>
<td>17.504</td>
<td></td>
</tr>
</tbody>
</table>

Note. *p < .05.

Table 3 presents the descriptive statistics of four skills. The results showed that listening ($t = 2.741, p = .008$) and reading ($t = 3.791, p = .000$) exhibited significant differences between the two groups, showing that the experimental group outperformed the control group. However, although the experimental group achieved higher mean values in both skills, the results showed no significant difference in speaking ($t = 0.173, p = .863$) and writing ($t = 1.476, p = .147$) performance between the two groups.

Table 3. Descriptive statistics for four skills

<table>
<thead>
<tr>
<th>Item</th>
<th>Experimental group</th>
<th>Control group</th>
<th>t</th>
</tr>
</thead>
<tbody>
<tr>
<td>Listening</td>
<td>36.22 (5.764)</td>
<td>31.11 (7.713)</td>
<td>2.741*</td>
</tr>
<tr>
<td>Speaking</td>
<td>11.20 (1.633)</td>
<td>11.11 (2.025)</td>
<td>0.173</td>
</tr>
<tr>
<td>Reading</td>
<td>26.40 (4.664)</td>
<td>20.56 (6.265)</td>
<td>3.791*</td>
</tr>
<tr>
<td>Writing</td>
<td>15.72 (3.156)</td>
<td>14.11 (4.619)</td>
<td>1.476</td>
</tr>
</tbody>
</table>

Note. *p < .05.

Learning motivation

The calculated Cronbach’s alpha reliability for the IMMS of the experimental group and control group were 0.826 and 0.903 respectively. Both Cronbach’s alpha values exceeded 0.8, indicating that the instrument used for assessing student motivation in this research was highly reliable.

The IMMS adopted in the experiment contained 29 questionnaire items with a Likert rating scale coded from 1 to 5, so the total score for the instrument could get the range from 29 to 145. The total scores of the 25 participants in the experimental group ranged from 121 to 145 with a mean value of 135.20 ($SD = 6.994$). The total scores of the 27 participants in the control group ranged from 70 to 140 with a mean value of 107.66 ($SD = 20.647$). The two-tailed unequal variances $t$-test shown in Table 4 revealed that the motivation level of the experimental group was significantly higher than the control group, where $t = 6.749$, $df = 35.222$, $p = .000$. Table 4 also shows that the experimental group yielded the significant higher mean scores than the control group at the 0.05 level in 4 scales of the ARCS model.

Table 4. Descriptive statistics for ARCS model in both groups

<table>
<thead>
<tr>
<th>Scale</th>
<th>Experimental group</th>
<th>Control group</th>
<th>t</th>
</tr>
</thead>
<tbody>
<tr>
<td>Attention</td>
<td>51.12 (2.948)</td>
<td>39.35 (8.006)</td>
<td>6.952*</td>
</tr>
<tr>
<td>Relevance</td>
<td>23.00 (1.779)</td>
<td>21.44 (2.860)</td>
<td>2.347*</td>
</tr>
<tr>
<td>Confidence</td>
<td>32.24 (2.554)</td>
<td>23.97 (6.790)</td>
<td>6.082*</td>
</tr>
<tr>
<td>Satisfaction</td>
<td>28.84 (1.434)</td>
<td>22.90 (5.512)</td>
<td>5.591*</td>
</tr>
<tr>
<td>Total</td>
<td>135.20 (6.994)</td>
<td>107.66 (20.647)</td>
<td>6.749*</td>
</tr>
</tbody>
</table>

Note. *p < .05.

The 12 questions shown in Table 5 are for the Attention factor in ARCS model. All responses obtained from the participants in the experimental group had a mean value above 4.0. Furthermore, all mean values were significantly higher than the ones of the control group, indicating that the robot-assisted instructional materials in EFL course could cause the positive impact on students’ attention.

Table 6 shows the mean values and standard deviations for 5 questions for the Relevance factor in ARCS model. In both groups, all items had a mean value above 4.0, indicating that the participants in both groups agreed that the content of the teaching materials in this experiment was relevant to the learning objectives of the course. Table 6 showed that the experimental group had a significant higher mean values at the 0.05 level in item 13 ($M = 4.72$, $SD =
0.458, \( t = 2.659, p = 0.012 \) and item 26 (\( M = 4.76, SD = 0.436, t = 2.515, p = 0.016 \)). The result of the item 13 indicated that there was a positive relationship between the learning interest and the robot-assisted materials. The result of the item 26 showed that the students in the experimental group agreed that the robot-assisted materials could be useful for learning the course. However, the results of item 7 and item 8 were very similar between the two groups. Surprisingly, the score of the control group was higher than the one of the experimental group. The two results indicated that even without the assistance of the educational robots in the course, the students in the control group still agreed that the teaching content was important and worthy of learning. Thus students seemed to rely on the book more when there was no presence of the robot. That is, these Taiwanese learners of English were highly dependent on the textbook because it could be the main and crucial source of the examinations.

**Table 5.** Descriptive statistics for the attention factor

<table>
<thead>
<tr>
<th>Item no.</th>
<th>Experimental group</th>
<th>Control group</th>
<th>( t )</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>( M )</td>
<td>( SD )</td>
<td>( M )</td>
</tr>
<tr>
<td>1</td>
<td>4.60</td>
<td>0.577</td>
<td>3.97</td>
</tr>
<tr>
<td>6</td>
<td>4.44</td>
<td>0.961</td>
<td>3.79</td>
</tr>
<tr>
<td>9</td>
<td>4.72</td>
<td>0.458</td>
<td>3.55</td>
</tr>
<tr>
<td>12</td>
<td>4.80</td>
<td>0.500</td>
<td>3.45</td>
</tr>
<tr>
<td>14</td>
<td>4.84</td>
<td>0.374</td>
<td>4.00</td>
</tr>
<tr>
<td>16</td>
<td>4.48</td>
<td>0.770</td>
<td>3.38</td>
</tr>
<tr>
<td>18</td>
<td>4.48</td>
<td>0.823</td>
<td>3.52</td>
</tr>
<tr>
<td>19</td>
<td>4.56</td>
<td>0.650</td>
<td>3.83</td>
</tr>
<tr>
<td>22</td>
<td>4.76</td>
<td>0.523</td>
<td>3.62</td>
</tr>
<tr>
<td>23</td>
<td>4.76</td>
<td>0.523</td>
<td>2.55</td>
</tr>
</tbody>
</table>

*Note.* \( *p < .05 \).

**Table 6.** Descriptive statistics for the relevance factor

<table>
<thead>
<tr>
<th>Item no.</th>
<th>Experimental group</th>
<th>Control group</th>
<th>( t )</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>( M )</td>
<td>( SD )</td>
<td>( M )</td>
</tr>
<tr>
<td>4</td>
<td>4.56</td>
<td>0.651</td>
<td>4.07</td>
</tr>
<tr>
<td>7</td>
<td>4.64</td>
<td>0.490</td>
<td>4.69</td>
</tr>
<tr>
<td>8</td>
<td>4.32</td>
<td>0.802</td>
<td>4.45</td>
</tr>
<tr>
<td>13</td>
<td>4.72</td>
<td>0.458</td>
<td>4.07</td>
</tr>
<tr>
<td>26</td>
<td>4.76</td>
<td>0.436</td>
<td>4.17</td>
</tr>
</tbody>
</table>

*Note.* \( *p < .05 \).

**Table 7.** Descriptive statistics for the confidence factor

<table>
<thead>
<tr>
<th>Item no.</th>
<th>Experimental group</th>
<th>Control group</th>
<th>( t )</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>( M )</td>
<td>( SD )</td>
<td>( M )</td>
</tr>
<tr>
<td>2</td>
<td>4.20</td>
<td>0.707</td>
<td>2.93</td>
</tr>
<tr>
<td>5</td>
<td>4.60</td>
<td>0.577</td>
<td>2.79</td>
</tr>
<tr>
<td>10</td>
<td>4.80</td>
<td>0.500</td>
<td>4.21</td>
</tr>
<tr>
<td>15</td>
<td>4.88</td>
<td>0.332</td>
<td>3.28</td>
</tr>
<tr>
<td>20</td>
<td>4.36</td>
<td>0.757</td>
<td>3.45</td>
</tr>
<tr>
<td>27</td>
<td>4.64</td>
<td>0.757</td>
<td>3.41</td>
</tr>
<tr>
<td>28</td>
<td>4.76</td>
<td>0.523</td>
<td>3.90</td>
</tr>
</tbody>
</table>

*Note.* \( *p < .05 \).

Table 7 shows the mean values and standard deviations for 7 questions for the Confidence factor in ARCS model. These items were used to find out the perception of difficulty and confidence toward the learning materials. All items had a mean value above 4.0 in the experimental group, and this mean value was significantly higher than the one in the control group. The results revealed that the majority of students in the experimental group increased confidence after learning the robot-assisted materials.
Table 8 shows the mean values and standard deviations of 6 questions for the Satisfaction factor in ARCS model. Again, all items had a mean value above 4.0 in the experimental group, and this value was significantly higher than the one in another group. The results showed that the level of satisfaction in the experimental group was higher than the one of the control group.

Table 8. Descriptive statistics for the Satisfaction factor

<table>
<thead>
<tr>
<th>Item no.</th>
<th>Experimental group</th>
<th>Control group</th>
<th>t</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M</td>
<td>SD</td>
<td>M</td>
</tr>
<tr>
<td>3</td>
<td>4.72</td>
<td>0.542</td>
<td>3.79</td>
</tr>
<tr>
<td>11</td>
<td>4.76</td>
<td>0.436</td>
<td>4.03</td>
</tr>
<tr>
<td>17</td>
<td>4.72</td>
<td>0.542</td>
<td>3.31</td>
</tr>
<tr>
<td>21</td>
<td>4.92</td>
<td>0.277</td>
<td>4.41</td>
</tr>
<tr>
<td>25</td>
<td>4.76</td>
<td>0.436</td>
<td>3.55</td>
</tr>
<tr>
<td>29</td>
<td>4.96</td>
<td>0.200</td>
<td>3.79</td>
</tr>
</tbody>
</table>

Note. *p < .05.

The teacher’s opinions

After the experiment, the instructor was interviewed again and she provided the following opinions. The positive opinions regarding students’ learning achievement are listed first followed by the limitations of the learning materials.

- The robot could make the learning meaningful, create better interaction, and encourage risk-taking courage. That is, students were more willing to take challenges and speak up.
- The student-talk rate and the ratio of giving responses were also increased. When a robot was used in class, more students were willing to get involved in giving responses.

The following suggestions were made by the teacher in order to improve the weaknesses of the robot system.

- Comparing with the preparation of the typical multimedia slides, I needed one to two extra hours for authoring the robot-assisted materials to edit the robot’s movements if there were no appropriate movements I needed. I think it is necessary to be proficient in the authoring tool.
- Perhaps the movement of the robot should be more natural and diverse in order to fit in more teaching contents and draw more of attention.
- It might be better if the RALL system could have supplied ready-made templates in order to relieve teachers’ burden of designing the robot teaching contents or making new and supplementary materials.

Discussion

Our robotic-assisted lessons showed that students studying in our course had better learning outcome comparing to those who did not learn in the same way. The experimental group students gave positive responses to the learning. They agreed that the robot-assisted materials were easy to learn so they were satisfied. In other words, their anxiety level was lower and their self-esteem was better, so that their confidence, satisfaction, and attention could be significantly different from those studying in a class without the help of a robot.

The most important finding is that our robotic syllabus did not just help with learners’ positive thinking in the learning process, but to sustain their better learning motivation and language competence. Gardner (2007), for example, stressed that materials and activities in learning environment affect students’ external motivation, and motivation affect learning ability. This has been confirmed via our research because learners in our experimental group gained higher scores in the listening, speaking, reading and writing tests at the end of learning stage. In particular, learners in this group had significant achievement (p < .05) in the listening and reading tests. Overall, our results could infer that using robotic instructional tools integrated with multimedia materials and appropriate activities might positively influence on the learning of EFL.
Although some may argue that our teaching design in this study made no significant impact on speaking and writing, it is important to be aware that the goal of EFL at the early stage of the elementary level in Taiwan is to spend more time training of listening and reading skills instead of communicating and writing skills. Normally, the major teaching activities taking a big portion of time in class are that teachers read aloud, act out stories, or present other listening materials for students to immerse in native-speaker’s accents. Having these common teaching objectives in mind, our materials have used a robot to act out as a native speaker to execute the storytelling activity and interact with students, so the students interacting with a robot had significant improvement comparing to those without. This finding is in the same line with other studies in RALL. Overall, the positive emotional states of language learners along with students’ engagement in learning were found to be quite important to decide the success of L2 acquisition (e.g., Lightbown & Spada, 2006).

Conclusion

This research proposed a RALL framework to design one kind of robot-assisted instructional materials for elementary students in EFL education in Taiwan. Our results exhibited that comparing to those in a regular basis without the presence of a robot, the experimental group of students had better improvement on motivation, attention, confidence, acceptance of the teaching materials, satisfaction in the learning process, and language ability. Thus, adopting robot-assisted instructional materials in the primary level of English language teaching in Taiwan can be promoted.

It is worthwhile noticing that the two receptive language skills, listening and reading skills, could have obvious progress. Such achievements could be supported by the fact that students learning with a robot had better attention, greater joy, and less tension. This finding can support Krashen’s (1982) popular claim regarding “Affective Filter Hypothesis”: the more positive and less anxious learners’ psychological state is, the better language ability can be acquired. Overall, our study concludes that elementary school students in Taiwan can learn English listening and reading via the robotic instructional tool to naturally raise their attention and reduce their anxiety. Nevertheless, the current practice of EFL in such a context still needs to make more efforts in developing digital reading and listening materials along with the aid of a robot as a tutor that can really monitor and record students’ attention level to enhance their language acquisition.

There are limitations and future development of our research. First, according to the Hawthorne Effect, results of our experiment were not solid enough to conclude that the robot was the only one parameter to influence the learning performance. Then our future work is going to survey a most used tangible instructional tool similar to robots, such as puppets. That is, the students learn with puppet-assisted multimedia materials can be an active control group, and we can investigate if robot-assisted materials still support a significant impact. Second, according to the teacher’s opinions in our survey, the teacher who was not a computer professional would spend more time learning our authoring tool to design the robot’s movements. Thus, to convince and promote our RALL framework for elementary EFL classes, we need to create more movements of the robots in our next version of the RALL. Finally, as the results of our experiment exhibited that students increased a talking rate via the stimulus of the robot, a further research issue can survey if our RALL framework positively reduces students’ anxiety and fear of communication with others in English.

Acknowledgements

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References


Development and Validation of the Perception of Students Towards Online Learning (POSTOL)

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ABSTRACT

In the twenty-first century, online learning has evolved as a worldwide platform to connect, collaborate and engage users in the learning process. Online learning today is integrated with social network connectivity, which builds an ecosystem for interaction between students, teachers, and professors from every corner of the world, providing them with free and accessible online resources. However, in order to promote active engagement of the learners and delivery of meaningful learning in the online learning settings, it is also necessary to determine students’ perceptions towards online learning. The aim of this study was to develop a scale for determining students’ perceptions of online learning (POSTOL). This scale consists of four dimensions: instructor characteristics, social presence, instructional design, and trust. Research data was collected from 208 Taiwan university students. In order to determine the validity of the scale, exploratory factor analysis, and confirmatory factor analysis and item discrimination was used. Results showed that the POSTOL is a valid and reliable instrument. The implications of the present study are important for instructional designers, educators, and institutions that are planning to offer, or are currently offering, online courses.

Keywords

Online learning, Instructor characteristics, Social presence, Instructional design, Trust

Introduction

With the recent advancement in information and communication technology (ICT), in the twenty-first century, the Internet plays an important role for accessing instruction from anywhere (Davies, Dean, & Ball, 2013; Jones, Johnson-Yale, Millermaier, & Pérez, 2008; Means, Toyama, Murphy, & Baki, 2013). The use of the Internet in higher education has grown at an exponential rate (OECD, 2010). There is a high level use of the Internet, particularly in university education (Judd & Kennedy, 2010). Crook (2008) pointed out that the Internet is not only providing access to the large learning contents but also providing opportunities to interact with other people by sharing their ideas and participating in discussion forums across the globe. The integration of the Internet in a face-to-face learning environment has shown a positive effect on academic achievement (Bernard et al., 2004).

As stated in Миниаватс Маркетинг Групп (2015), Taiwan had a population of 23,359,928 in 2014 and 18,687,942 Internet users as of Dec 31, 2013, which accounts for 80% of the population. Also, there were 23 million 3G subscribers, equivalent to about 75% of the total mobile subscribers. In addition, smart phone penetration in Taiwan has increased to 51% of the total population. In fact, 69% of the population access their smart phones daily (Ipsos MediaCT, 2013). This indicates that a large percentage of Taiwan’s students can access the Internet on their smart phones, use social networking sites, and connect themselves wirelessly.

Theoretical framework

Online learning and its effectiveness

There are many definitions of “online learning” given by the researchers. For example, according to Benson (2002), online learning is an improved version of distance learning. Khan (2005, p. 3) defined online learning as “an innovative approach for delivering a well-designed, learner-centered, interactive, and facilitated learning environment to anyone, anyplace, anytime by utilizing the attributes and resources of various digital technologies along with other forms of learning materials suited for open, flexible, and distributed learning environments.”
another definition, Zhu, McKnight, and Edwards (2009) described online instruction as any formal educational process in which the instruction occurs when the learner and the instructor are not in the same place, and Internet technology is used to provide a communication link between the instructor and students. Learning via a computer network, such as the Internet and the World Wide Web, a local area network (LAN), or an intranet is considered online learning (Harasim, 2012).

Many studies have found the positive outcomes of online learning environments. Gürsul and Keser (2009) compared online and face-to-face problem-based learning environments in mathematics. They found that students in the online problem-based learning group performed better than the students in the face-to-face problem-based learning group. In another study, Hofman (2002) advocated that online courses help the students to understand the course content more easily and effectively. Vrasidas and McIsaac (2000) added that both synchronous and asynchronous types of learning motivate the students for self-paced learning. Learners became more independent and responsible after taking online courses (Schoech, 2000). Other findings indicated that students were satisfied by the introduction of information and communication technology (ICT) in face-to-face classrooms and held positive attitudes in accepting online courses (Sagın Simsek, 2008). According to Michau, Gentil, and Barrault (2001), online courses provide flexibility in terms of time and location and are also cost-effective.

**Measures of student’s perception towards online learning**

Over the past few years, many studies have developed scales about students’ perceptions towards online learning. Smith, Murphy, and Mahoney (2003) conducted a study to examine the instrument developed by McVay (2000). They identified “comfort with e-learning” and “self-management of learning” as two important factors after factor analysis. Later, Smith (2005) again tested McVay’s (2000) instrument using a sample of 314 Australian university students. The study revealed that this instrument may be applied for research and practice within the area of student preferences towards online learning. However, Hung, Chou, Chen, and Own (2010) argued that online learner readiness should include technical computer skills, Internet skills, and learner control over the sequence and selection of course materials, which were not present in McVay’s (2000) instrument. Hung et al. developed the Online Learning Readiness Scale (OLRS). The OLRS included some important dimensions such as self-directed learning, motivation for learning, computer/Internet self-efficacy, learner control, and online communication self-efficacy but lacked other important dimensions such as instructor characteristics, social presence, instructional design, and trust. Based on the aforementioned dimensions to examine students’ perception toward online learning, the current study aimed to develop a scale that could be better applied to depict contemporary settings of online learning.

**Instructor characteristics**

Instructor characteristics, as defined by Lee, Yoon, and Lee (2009), is the extent to which instructors are caring, helpful, and accommodating to students. Lim, Hong, and Tan (2008) mentioned that students were not actively engaged in the e-learning system unless they were guided and facilitated by instructors who were also active in using the e-learning system. If interactions between students and instructors as well as among students are promoted, enhanced social presence can improve students’ motivation, emotions, cognitive processes, and learning (Kim, Park, & Cozart, 2013). Vrasidas and McIsaac (2000) suggested that the instructor provide feedback in a regular manner and also take part in discussions. Heuer and King (2004) regarded the online instructor as facilitator, model, planner, coach, and communicator. Lim, Morris and Yoon (2006) analyzed the quality of online instruction, learning motivation, and learning involvement as significant variables influencing the course outcomes of the online learning program. Therefore, the instructor plays a vital role in online learning environments.

**Social presence**

The concept of social presence was introduced by Short, Williams, and Christie (1976, p. 65). They defined social presence as the “degree of salience of the other person in a mediated communication and the consequent salience of their interpersonal interactions.” In another definition, Tu and McIsaac (2002) defined social presence as “a measure
of the feeling of community that a learner experiences in an online environment” (p. 131). According to Tu (2000), social presence helps enhance and foster online interaction, which initiates social learning. Wei, Chen, and Kinshuk (2012) supported the idea that social presence initiates learning interaction in an online classroom, resulting in improved learning performance. Social presence is a vital component that influences online interaction (Tu & McIsaac, 2002). Ning Shen and Khalifa (2008) considered social presence as a major design principle in computer-mediated community and an important determinant of online community participation. Therefore, social presence can be seen as one considerable factor.

**Instructional design**

One’s mental effort to interact with the certain amount of information at one time is known as cognitive load. This “load” should be considered thoroughly when designing instructional materials, particularly for the online learning environment. The cognitive load theory focuses on the limitations of human working memory to determine the effectiveness of instruction and has been recognized as a framework for research in cognitive process and instructional design (Paas, Renkl, & Sweller, 2003). The theory suggests that instruction should be designed within the capacity of working memory to achieve optimal learning outcomes (Kirschner, 2002). Working memory (WM) can be described as little pieces of information a learner can temporarily retain in the mind while simultaneously allowing instant access to the newer or additional acquisition of information (Cowan, 2005). Information is held in WM enabling processing and manipulating for compilation of more complex tasks such as comprehension or reasoning (Baddeley, 2000).

When the presented information is beyond the amount of mental effort the learner can offer, WM may be overloaded and learning is limited. On the other hand, when the presented information is too little, then the mental effort consumed by the learners is less and, as a result, learning is inefficient (Cook, 2006). Too little information does not engage learners in a way that restructures their existing memory to incorporate the new information and store it for future usage (Lohr, 2008).

Intrinsic, extraneous, and germane cognitive loads are used to measure such mental effort. To be specific, intrinsic load is directly related to the nature of the content complexity delivered to the learners, and their expertise (Paas et al., 2003); extraneous (ineffective) load can be referred to the extraneous elements designated during the instruction, which can impose one’s extra effort to WM, and may indirectly hinder learning (Mayer, 2009); and germane (effective) load refers to the extra effort devoted by the learners to facilitate learning (Paas et al., 2003). Wu (2011) pointed out that an instructional design of a course might be ineffective when learners are cognitive overloaded (i.e., sum of extraneous, intrinsic, and germane load exceeds cognitive capacity of the learners). Wang and Newlin (2002) suggested student-centered course design, which will reduce the anxiety levels related with online courses. Thus, a well-designed online course should reflect the course designer’s thorough design process and teaching experiences that specifically concern the aforementioned cognitive loads.

**Trust**

Grandison and Sloman (2000) defined trust as “the firm belief in the competence of an entity to act dependably, securely and reliably within a specified context” (p. 4). Wang (2014) emphasized that building and maintaining trust are very important for the success of online course as it will reduce the dropout rate. Sahin and Shelley (2008) also pointed out that if the students believe that the online course is useful, they will more enjoy that course. From the above studies, we conclude that trust towards online learning is an important dimension of student’s perception about online learning.

In summary, there are some essential dimensions for online learning, which have not been previously studied. The aim of this study is to integrate those essential dimensions (instructor characteristics, social presence, instructional design, and trust), and to develop and validate a new scale: perception of students towards online learning (POSTOL).
Methodology

Participants and data collection

A sample of 208 responses was collected from different parts of Taiwan. Students with different educational backgrounds (undergraduate, master or doctoral) and online learning experience responded using a Google online survey. The demographic information includes gender, age and educational background. As shown in Table 1, about 53.8% were female students and 46.2% were male students. Approximately 46.2% were undergraduates; 45.7% were masters, and 8.2% were PhD students. The important point that we can observe is that approximately 89.9% of students have smartphones and 98.6% have Facebook accounts. If we observe daily Internet use, approximately 59.1% of participants use the Internet more than five hours daily. This reveals that participants have a moderate or higher level of Internet experience.

<table>
<thead>
<tr>
<th>Measure</th>
<th>Category</th>
<th>Number</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td>Female</td>
<td>112</td>
<td>53.8</td>
</tr>
<tr>
<td></td>
<td>Male</td>
<td>96</td>
<td>46.2</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>208</td>
<td>100</td>
</tr>
<tr>
<td>Age (years)</td>
<td>18–25</td>
<td>141</td>
<td>67.78</td>
</tr>
<tr>
<td></td>
<td>26–30</td>
<td>27</td>
<td>12.98</td>
</tr>
<tr>
<td></td>
<td>31–35</td>
<td>19</td>
<td>9.13</td>
</tr>
<tr>
<td></td>
<td>36 and above</td>
<td>21</td>
<td>10.09</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>208</td>
<td></td>
</tr>
<tr>
<td>Education</td>
<td>Undergraduate</td>
<td>96</td>
<td>46.2</td>
</tr>
<tr>
<td></td>
<td>Master</td>
<td>95</td>
<td>45.7</td>
</tr>
<tr>
<td></td>
<td>PhD</td>
<td>17</td>
<td>8.2</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>208</td>
<td></td>
</tr>
<tr>
<td>No. of smartphone users</td>
<td>Yes</td>
<td>187</td>
<td>89.9</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>21</td>
<td>10.1</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>208</td>
<td></td>
</tr>
<tr>
<td>No. of Facebook users</td>
<td>Yes</td>
<td>205</td>
<td>98.6</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>3</td>
<td>1.4</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>208</td>
<td></td>
</tr>
<tr>
<td>Frequency of daily Internet use</td>
<td>Frequently(&gt; 5 hours)</td>
<td>123</td>
<td>59.1</td>
</tr>
<tr>
<td></td>
<td>Normally(3–4 hours)</td>
<td>69</td>
<td>33.2</td>
</tr>
<tr>
<td></td>
<td>Occasionally(1–2 hours)</td>
<td>15</td>
<td>7.2</td>
</tr>
<tr>
<td></td>
<td>Rarely(&lt; 1 hour)</td>
<td>1</td>
<td>0.5</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>208</td>
<td></td>
</tr>
</tbody>
</table>

Item generation

The survey instrument used in the study contained six items of personal information. Another 16 items were divided into four dimensions: instructor characteristics, social presence, instructional design, and trust (see Appendix for statements in each dimension). To maintain the content validity of the instrument, a panel of five experts reviewed the items of each dimension. The instructor characteristics dimension was composed of five items based on Lim et al. (2008). The social presence dimension comprised five items based on Lim et al. (2008), and Sahin and Shelley (2008). The instructional design dimension consisted of three items based on Mullen & Tallent-Runnels (2006). The trust dimension was composed of three items based on House, Weldon, and Wysocki (2007) and Otter et al. (2013). Except for demographic information, all the survey items were measured on a five-point Likert scale, with 1 signifying strongly disagree and 5 signifying strongly agree.
Data analysis

The data collected was analyzed using SPSS 21 and AMOS 21. To determine the factor structure, researchers used an exploratory factor analysis (EFA) using principal component analysis with varimax rotation. In the next stage, confirmatory factor analysis (CFA) was used to establish structural validity of the scale. The most commonly used indices to examine the model obtained were the root mean square error approximation (RMSEA), comparative fit index (CFI), goodness-of-fit indexes (GFI), the normed fit index (NFI), and the Tucker-Lewis coefficient (TLI). RMSEA values lower than .05 are indicative of a close fit, values ranging from .05 to .08 are indicative of a reasonable fit, and values greater than or equal to .09 are considered a poor fit (MacCallum, Browne, & Sugawara, 1996). Values of CFI, GFI, NFI, and TLI greater than 0.9 indicate a good fit of the model (Hair et al., 2006; Hu & Bentler, 1999; Kline, 2005).

Sampling adequacy for the factor analysis

There were no missing values in the data. The normality of the data was examined through inspection of skewness and kurtosis. From the findings, the skewness (instructor characteristics = 1.331; social presence = .940; instructional design = .723; trust = -.113) and kurtosis (instructor characteristics = 2.039; social presence = 1.316; instructional design = .416; trust = .420) values are within recommended cutoffs of |3| and |10| for skewness and kurtosis, respectively (Kline, 2005). This ensures the normality of the data. In addition, results from the Kaiser–Meyer–Olkin measure of sampling adequacy (KMO) (0.896) and Bartlett’s test of sphericity ($\chi^2 (120) = 2022.469, p < .001$) indicated that the data was appropriate for the factor analysis to proceed.

Results

Exploratory factor analysis for POSTOL

Researchers used a principal component analysis (PCA) with varimax rotation to determine the factor structure from the data collected. An initial analysis was run to obtain eigenvalues for each factor in the data. According to Hair et al. (2006), only the factors with an eigenvalue greater than 1 are considered representative. The four factors accounted for 61.853% of the total variance, and overall Cronbach’s alpha of the scale was .906. The first factor, instructor characteristics, with an eigenvalue of 7.062, included five items (Cronbach’s alpha = .920). The second factor, “social presence,” with an eigenvalue of 2.232, included five items (Cronbach’s alpha = .90). The third factor, “instructional design,” with an eigenvalue of 1.207, included three items (Cronbach’s alpha = .727). The fourth factor, “trust,” with an eigenvalue of 1.003, included three items (Cronbach’s alpha = .732). Table 2 shows the factor loadings after rotation.

<table>
<thead>
<tr>
<th>Item</th>
<th>Factor 1</th>
<th>Factor 2</th>
<th>Factor 3</th>
<th>Factor 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>IC 1</td>
<td>.973</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IC 2</td>
<td>.866</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IC 3</td>
<td>.830</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IC 4</td>
<td>.711</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IC 5</td>
<td>.708</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SP 1</td>
<td></td>
<td>.833</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SP 2</td>
<td></td>
<td>.817</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SP 3</td>
<td></td>
<td>.808</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SP 4</td>
<td></td>
<td>.741</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SP 5</td>
<td></td>
<td>.600</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ID 1</td>
<td></td>
<td></td>
<td>.750</td>
<td></td>
</tr>
</tbody>
</table>
Confirmatory factor analysis

Confirmatory factor analysis was then undertaken, using AMOS 21.0.0, to establish the structural validity of the scale. As given in Table 3, CFA resulted in satisfactory indices ($\chi^2$ (96) = 176.783, $p < .001$; RMSEA = .064; CFI = .959; GFI = .914; NFI = .915; TLI = .949) indicating that the four-factor model, obtained in EFA, was best of the fit.

Table 3. Model fit measurement statistics

<table>
<thead>
<tr>
<th>Fit index</th>
<th>POSTOL</th>
<th>Recommended value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chi-square ($\chi^2$)</td>
<td>176.783</td>
<td>–</td>
</tr>
<tr>
<td>Degree of freedom (DF)</td>
<td>96</td>
<td>–</td>
</tr>
<tr>
<td>$\chi^2$/DF</td>
<td>1.841</td>
<td>$\leq 5$</td>
</tr>
<tr>
<td>RMSEA</td>
<td>.064</td>
<td>$\leq .08$</td>
</tr>
<tr>
<td>CFI</td>
<td>.959</td>
<td>$\geq .90$</td>
</tr>
<tr>
<td>GFI</td>
<td>.914</td>
<td>$\geq .90$</td>
</tr>
<tr>
<td>NFI</td>
<td>.915</td>
<td>$\geq .90$</td>
</tr>
<tr>
<td>TLI</td>
<td>.949</td>
<td>$\geq .90$</td>
</tr>
</tbody>
</table>

Convergent and discriminant validity

In addition to model fit indices, in order to examine the validity of the scale, it is also necessary to estimate composite reliability (CR) and average variance extracted (AVE), which can be obtained from CFA (Fornell & Larcker, 1981; Hair et al., 2006). According to Hair et al. (2006), for convergent validity, the factor loadings of each item should be greater than 0.7, CR should be at least 0.7 and AVE should be greater than 0.5. The factor loadings obtained from CFA were greater than 0.7, giving evidence for convergent validity. As given in Table 4, CR values for instructor characteristics, social presence, instructional design, and trust were 0.733, 0.914, 0.902, and 0.740, respectively, which satisfied the value of 0.7. The AVE for social presence and instructional design are greater than 0.5, but for the other two less than 0.5. Fornell and Larcker (1981) mentioned that for discriminant validity, the square root of the AVE of each construct should be greater than the correlation between the construct and other constructs in the model and should be at least 0.50. From Table 5, it is confirmed that square root of the AVE of all constructs are significantly greater than the inter-construct correlations. This confirms the convergent and discriminant validities of the scale.

Table 4. (CR) and (AVE) of confirmatory factor analysis

<table>
<thead>
<tr>
<th>Measures</th>
<th>Items</th>
<th>Composite reliability (CR)</th>
<th>Average variance extracted (AVE)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Instructor characteristics</td>
<td>5</td>
<td>0.733</td>
<td>0.480</td>
</tr>
<tr>
<td>Social presence</td>
<td>5</td>
<td>0.914</td>
<td>0.682</td>
</tr>
<tr>
<td>Instructional design</td>
<td>3</td>
<td>0.902</td>
<td>0.650</td>
</tr>
<tr>
<td>Trust</td>
<td>3</td>
<td>0.740</td>
<td>0.492</td>
</tr>
</tbody>
</table>
Table 5. Correlations among constructs (square root of AVE in diagonal)

<table>
<thead>
<tr>
<th></th>
<th>Instructor characteristics</th>
<th>Social presence</th>
<th>Instructional design</th>
<th>Trust</th>
</tr>
</thead>
<tbody>
<tr>
<td>Instructor characteristics</td>
<td>0.692</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Social presence</td>
<td>0.126</td>
<td>0.826</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Instructional design</td>
<td>0.480</td>
<td>0.683</td>
<td>0.806</td>
<td></td>
</tr>
<tr>
<td>Trust</td>
<td>0.285</td>
<td>0.636</td>
<td>0.692</td>
<td>0.702</td>
</tr>
</tbody>
</table>

*Note.* Diagonal elements (in bold) represent the square root of the AVE.

Discussion and conclusion

The present study aimed to develop a scale (POSTOL) to measure student’s perceptions of online learning. The survey form was administered to 208 students from Taiwan for reliability and validity. The exploratory factor analysis revealed a four-factor structure solution that accounted for 61.85% of the total variance, and the overall Cronbach’s alpha of the scale was .906. Next, the confirmatory factor analysis supported the four-factor structure: instructor characteristics, social presence, instructional design and trust. All the constructs satisfied the conditions of reliability and discriminant validity. Statistical analyses showed that the scale (POSTOL) is a valid and reliable instrument.

In comparison, with the previous scales developed by Smith et al. (2003) and Hung et al. (2010), the present scale displayed more contemporary factors, which plays an important role in the student’s preference in online learning. Instructors play multiple roles starting from the delivery of meaningful learning to active engagement of the students. This finding is supported by Lim et al. (2008). Social presence can help the instructional designers to maintain the quality of online learning experience, which is consistent with Wei et al. (2012). The factor of instructional design includes individual differences and student-centered course design, which will motivate the students to participate in the online learning settings, which is consistent with the previous study conducted by Wang and Newlin (2002). Learners’ trust towards the online course is the ultimate key for the successful implementation of online learning. This result is consistent with the findings that if the students are satisfied with an online course, they will enjoy the course more (Sahin & Shelley, 2008).

It is recommended that further research should be carried out to check the psychometric properties of POSTOL in a diverse cultural context like India and at different stages of education. In addition, further research is needed to study the relationship between demographic variables and students’ perception towards online learning as well as to reconsider the course design of online learning, to the benefit of students. The present scale tried to overcome the shortcomings of the previous studies in the design of contemporary online courses, including instructor characteristics, social presence, instructional design, and trust. This study motivates instructional designers, educators, and institutions to improve the quality of future and current online courses.

Acknowledgements

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Both authors, Kaushal Kumar Bhagat and Leon Yufeng Wu, had contributed equally to this work.

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### Appendix

<table>
<thead>
<tr>
<th>Survey items</th>
<th>Item no.</th>
<th>Item</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Instructor Characteristics (IC)</strong></td>
<td>IC 1</td>
<td>Instructors should be friendly and approachable.</td>
</tr>
<tr>
<td></td>
<td>IC 2</td>
<td>Instructors should encourage student interactions.</td>
</tr>
<tr>
<td></td>
<td>IC 3</td>
<td>Instructors should provide sufficient learning resources online.</td>
</tr>
<tr>
<td></td>
<td>IC 4</td>
<td>Instructors should solve emerging problems efficiently.</td>
</tr>
<tr>
<td></td>
<td>IC 5</td>
<td>Instructors should provide fast feedbacks to queries in the discussion forum.</td>
</tr>
<tr>
<td><strong>Social Presence (SP)</strong></td>
<td>SP 1</td>
<td>This course would help me to use the Internet sources more efficiently.</td>
</tr>
<tr>
<td></td>
<td>SP 2</td>
<td>I think sharing knowledge through online discussions is a good idea.</td>
</tr>
<tr>
<td></td>
<td>SP 3</td>
<td>Online discussion enables students to exchange ideas and comments.</td>
</tr>
<tr>
<td></td>
<td>SP 4</td>
<td>I would benefit from using interactive applications.</td>
</tr>
<tr>
<td></td>
<td>SP 5</td>
<td>Browsing classmates’ works would help to improve the quality of my own work.</td>
</tr>
<tr>
<td><strong>Instructional Design (ID)</strong></td>
<td>ID 1</td>
<td>I differentiate between difficult and easier types of course content and study them differently.</td>
</tr>
<tr>
<td></td>
<td>ID 2</td>
<td>I like to involve myself actively in group discussions.</td>
</tr>
<tr>
<td></td>
<td>ID 3</td>
<td>Understanding the subject matter of this course is very important to me.</td>
</tr>
<tr>
<td><strong>Trust (TR)</strong></td>
<td>TR 1</td>
<td>Online courses should provide a better learning experience than traditional courses.</td>
</tr>
<tr>
<td></td>
<td>TR 2</td>
<td>I believe that I can earn better grade in an online course than in a traditional course.</td>
</tr>
<tr>
<td></td>
<td>TR 3</td>
<td>Students learn more in online courses than they learn in traditional courses.</td>
</tr>
</tbody>
</table>