Educational Technology & Society
An International Journal

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

- Educators aim to use technology to enhance individual learning as well as to achieve widespread education and expect the technology to blend with their individual approach to instruction. However, most educators are not fully aware of the benefits that may be obtained by proactively harnessing the available technologies and how they might be able to influence further developments through systematic feedback and suggestions.

- Educational system developers and artificial intelligence (AI) researchers are sometimes unaware of the needs and requirements of typical teachers, with a possible exception of those in the computer science domain. In transferring the notion of a ‘user’ from the human-computer interaction studies and assigning it to the ‘student’, the educator's role as the 'implementer/ manager/user' of the technology has been forgotten.

The aim of the journal is to help them better understand each other's role in the overall process of education and how they may support each other. The articles should be original, unpublished, and not in consideration for publication elsewhere at the time of submission to Educational Technology & Society and three months thereafter.

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Educational Technology & Society acknowledges the generous financial sponsorship provided by Centre for Research and Technology - Hellas, Informatics and Telematics Institute (CERTH/ITI), Greece towards the establishment of the print version of the journal.
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Participation in on-line courses - how essential is it?

Moderator & Summarizer:
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Discussion Schedule:
Discussion: 19-28 January 2004
Summing-up: 29-30 January 2004

Pre-Discussion Paper

Introduction

Groups of learners on online courses, in common with other online communities, are generally found to comprise both highly participative individuals and those who appear to contribute little to group discussions but who consider that they are actively following the course and learning. I use the neutral term ROPs (Read Only Participants) for the latter rather than the commonly used “lurker” which carries a suggestion of deviant behaviour.

The questions to be addressed in this discussion are to do with issues such as if ROPs on an online course are pursuing an inappropriate learning strategy on their part and, if so, what could be done by course designers and moderators to encourage learner participation.

Participation and collaborative learning

Question 1: What type of online course benefits most from a participation-rich approach or when should ROPing be discouraged?

Discussion and sharing experience have been identified as two of the most effective means by which adults learn (Brookfield, 1990; Brown and Duguid, 2000). But there is a difference between, for example, a course in a computer programming language and one in educational theory, the former arguably functioning satisfactorily with a course design based around an individual learner interacting with tutor and course material and moving through the course at their own pace whereas the latter would benefit more from a high degree of collaborative discussion and groupwork (with the implied logistical implications of a group of learners following the course in cohort).

But what about the (indignant) participant who says “I am participating even if I am not involved in discussion”? The existence of a variety of learning styles is now widely accepted and the inherent flexibility of online learning allows us to consider ways of catering for these. Should we then accept that “some people are like that” and accept this as a valid learning style/strategy.

John Seely Brown of PARC Xerox (Schrage, 2002) has applied the idea of the legitimate peripheral participant (LPP) originally used by Lave and Wenger (1990) in the broader context of situated learning, to the situation of online learning communities and sees it as having positive aspects:

“The culture of the Internet allows you to link, lurk, and learn. Once you lurk you can pick up the genre of that community, and you can move from the periphery to the center safely asking a question - sometimes more safely virtually than physically - and then back out again. It has provided a platform for perhaps the most successful form of learning that civilization has ever seen. We may now be in a position to really leverage the community mind”.

However, a question then follows about the value of legitimate peripheral participation for those people who are actively involved in the discussion. In a recent CPsquare project entitled “Let’s get more positive about the term lurker” (CPsquare Lurker Project, 2003) this phenomenon was discussed in some detail from a Communities of
Practice (CoP) perspective. They conclude that “(…) it is valid for participants to interact at different levels, depending on the context of the CoP (or discussion) and their learning needs. However, concern was expressed that while non contributors may be meeting their learning needs, the wider group needs active participants to ‘value add’ for all members in order to support the long term sustainability of the community. It was suggested that expected roles and contribution levels be discussed in the initial stages of the CoP, and renegotiated during the life of the CoP.”

**Measurement**

**Learner assessment and course evaluation**

**Question 2: What sort of participation profiling features should we be looking for in online learning environments?**

One of the great benefits of working online is that it is possible to keep track of learner and tutor written contributions. Most Virtual Learning Environments (VLEs) will allow tutors to keep track of how many messages are posted by each student per week and it is often possible to extract further information such as whether the post was initiating a thread or responding to a previous post.

In a small study on a 20 week online course I recorded the number of posts/week per learner and classified the posts into 3 groups:
- Group One initiated task-related discussion
- Group Two responded to task-related messages
- Group Three were non-task-related messages and replies

From this I went on to chart (using Excel) the participation profile of each learner and made some tentative conclusions about both the involvement of individuals throughout an extended course and also as to the type of activities/tasks that elicited a high degree of participation from learners.

David Wiley (Wiley, 2002) has proposed a more detailed mathematical approach to evaluating participation in multi-thread discussion by operationalizing the discussion and calculating an adjusted mean reply depth (d) for each participant where d could have the following values:

- **d value, possible interpretation:**
  - 0 to 0.3 Monologue or lecture; no discussion
  - 0.3 to 1.2 Simple Q & A; chit-chat
  - 1.2 and higher Discussion, Multilogue

Wiley’s approach could be applied in software environments that allow discussion threading (this was not possible in First Class in 2002 when I was doing the study mentioned above). I believe both approaches can be fairly time consuming and extracting and processing this information for large numbers of learners is a non-trivial task in many VLEs.

**Question 3: Should learner participation be assessed by the awarding of grades?**

This is something of a thorny question and I suspect there is no one answer.

On the one hand, if we are convinced that collaboration is an integral part of the learning process on a particular course, then one way of giving learners an incentive to participate is by grading it. Furthermore, if we as tutors see particular learners actively sharing ideas and knowledge, researching, reflecting and evolving while others remain stubbornly silent it seems to make sense to reflect this in the final assessment grade. Indeed, there is evidence from work by the Suny Learning Network that learners welcome this (Swan et al., 2003)

However measuring this in a transparent way is not easy and the process is also likely to encourage some course participants to post messages simply to maintain their posting averages thus leading to a worse signal/noise ratio and lowering the quality of collaboration.

At the same time, it could be argued that if we believe the kind of active learner involvement described above promotes learning, then perhaps it makes more sense to concentrate on developing more precise learning
assessment tools (portfolio, weekly reflection statements, theme papers) rather than grading participation itself i.e. aim to evaluate the outcome rather than the process.

Factors affecting participation

Question 4: What factors contribute to increasing and enhancing learner participation?

The Suny paper mentioned above (Swan et al., 2003 ) asserts that:

“The findings of the research on computer-mediated communication and asynchronous online learning are quite consistent. They point to three (and only three) course design factors that contribute significantly to the success of online courses. These are a transparent interface, an instructor who interacts frequently and constructively with students, and a valued and dynamic discussion.”

Putting aside for the moment the question of defining the success of online courses, would we agree that these are the key design factors? If so, what sort of characteristics of the interface, instructor and discussion do we need to be thinking about/promoting?

My own opinion, influenced by unpublished work in progress, is that the key to optimizing collaborative learning online lies in the learning tasks provided. Of course the moderator has to possess the necessary competencies (Salmon, 2000) and the virtual environment must be designed around on an appropriate pedagogical model, but it is the design and organization of the learning tasks which is the essential ingredient in facilitating the sort of active or engaged learning we have debated at some length on this forum in the past (IFETS, 2001).

Ludic participation

Question 5: Are ludic areas just a nice design extra or do they play a role in getting learners involved and participating in online environments?

Finally, moving to more specific aspects of learning environments I would like to refer to an area I believe deserves more attention - the role of virtual “student bars”, homesteads etc. which are found built into VLEs and learning platforms.

Personally, as a student on online courses, I have found that the idea of “dropping in” to a virtual bar/canteen to have a moan or share a joke and having my own “room” to decorate as I wish and invite visitors to, all go towards enhancing the feeling of individuality and of belonging to a community. This can make the virtual student experience a richer one and certainly helped me to log on regularly and to keep up my involvement with the course. On the other hand, fellow participants who “have not bothered” with these optional aspects appeared to successfully complete their courses and be satisfied with their learning achievements. I am not aware of research into this particular aspect.

References


Post-discussion Summary

What type of online course benefits?

While José Maria Barberán amplifies the tentative suggestion in my paper and considers two classes of courses "those like mathematics, anatomy, law..." and those like "sociology psychology and history..." with the latter benefiting more from collaborative work, David Kennedy challenges this sort of dichotomy and suggests that "if we want to accelerate learning we should aim to promote discussion" regardless of the nature of the subject. Bruce Jones reminds us that we need to consider both academic and corporate contexts and this raises a practical point which can be important to some online course providers: collaborative discussion and group-work imply a cohort of learners moving through a course and therefore a fixed timetable and course duration. On the other hand, the individual learner on a course could operate on a more flexible just-in-time basis and begin and end at any time. This can be attractive to course providers operating in a corporate context for example.

Rick Dilman asked some provocative questions:

1) Does evidence support the claim that group discussion is the best, or even a good, way to engender learning? (...) Unless this mode is extremely valuable, why bother?

2) Similarly, why is passive learning bad? If students meet their goals, whether these are to acquire certain information or to garner a certain number of credits, what difference does it make if they remain somewhat detached?" He explains that on a course of his, students are expected to "publicly display their knowledge" but that this not expected to necessarily lead to discussion. Bruce Jones comments that in his experience this is not adequate as is revealed when such students are unable to answer spontaneous questions from their peers.

Melissa Lee Price states that "most of our educational experience is passive, yet the research shows that in the educational exchange of: teacher-learner; learner-teacher; learner-learner the majority of the learning takes place in the learner-learner exchange" a point also made by Angel Medina. Bearing in mind Rick's question, and similar comments by Andrew McIntyre, I followed on from Melissa and Angel's comments to pose a pragmatic question: "When confronted by a skeptical colleague (or a cost-conscious senior decision-maker) what are the definitive studies you would cite to convince them that collaboration is the best route?" David Piper responded to this with arguments to convince decision-makers in a business training context, citing benefits such as reducing travel expenses, reducing drop out through isolation and the acquisition of important transferable skills.

The point which occurs to me in this regard is that, whereas in mature academic/scientific fields of investigation one usually finds major investigative studies which are recognized and accepted within the field and which support widely held viewpoints, in the area of online learning we do not seem to have arrived at that stage yet. There are various small/pilot studies which go towards supporting the view that many (but not all) of us here hold regarding the importance of the collaborative aspects of online learning but I perceive a lack of substantial authoritative studies on this (notwithstanding Stephen Downe's (2003) observation that “E-learning is more than a new way of doing the old thing. Its outcomes can’t be measured by the traditional process”).

Beverly Trayner has a different take on this and would "greatly mistrust any study that offered itself as the definitive study to show that there was (...) 'any best route for learning’". As Beverly sees it "It's an epistemological question and not one that could be resolved with any definitive study. Underlying any notion you have that collaborative learning is the best route is based on your assumptions about learning, teaching and the nature of knowledge." Beverly goes on to refer to some of the main theoretical works of the social-
constructivist theories of learning, situated learning and communities of practice which underpin current thinking on collaborative learning (Vygotsky 1978, Lave (1998); Brown, Collins & Duguid (1989); Lave & Wenger(1989)).

Bill Klemm, mentioning his webpage (http://www.cvm.tamu.edu/wklemm/collab.htm) of collaborative learning resources comments ruefully that “many people in higher education just don't "get it" when it comes to collaborative learning. No amount of evidence or argument will change their attitudes or behaviour.”

Beverly reminds us of the very important point that collaborative learning is more than just discussion and can involve a wide range of activities: "analyzing case studies, carrying out or mini-research projects, interactive lectures, study contracts, team model-building, joint problem solving .... or ....?"

This is neatly illustrated I think by Vladimir Formichov's description of how he organizes his online maths course so that there are incentives for those learners "with high mathematical skills" to take on a tutoring/problem solving role for less mathematically gifted colleagues. Apart from the obvious benefits this can bring to both groups of students (and the course tutor) Vladimir also mentions that it can have the additional advantage that if two students involved are in the same time-zone and the tutor not, it helps speed up response time when a student is stuck with a problem (a salutary reminder of time-zone logistics problems).

Beverly concludes by putting a question which came up in various guises: "are there situations where collaborative learning is certainly NOT the best route (e.g. in places where cost considerations outweigh real learning ones)?"

**Participation profiling features**

Janice Whatley is concerned that "monitoring student posting may have a negative effect on participation". I wonder if a well set out protocol explaining the motives and use of the profiling, which students read at the outset and sign, would go to allay such anxiety.

Bruce Jones has experimented with participation profiling and sees potential for it as "a learning tool" as does Mark Nichols, and I outlined a methodology I have employed for this. Ben Hyde raises the question of instruments to measure the activity of ROPs and suggests buttons which could allow them to quickly express a reaction to what they read. Ben mentions that Merlin and other VLEs allow us to see who have read a particular page. I commented that FirstClass additionally allows us to see who has printed out a particular page which can also be useful.

Ben also put forward an interesting suggestion regarding the benefits of access and participation statistics for each learner and tutor being made visible to all, given that VLEs like Blackboard already make this a possibility (and presumably when the Open Source resources of the Sakai Project (2003) are unveiled to an expectant world they will also provide this functionality).

**Should learner participation be rewarded by grades?**

(I am grateful to David Kennedy for gracefully reformulating this question early on).

Naomi Petersen provided us with a clear pedagogical framework for looking at this issue.

She reminds us that "participation (...) is valuable in an education context only when it benefits the learning , not the grading, of the student," and she goes on to set out how course, syllabus and evaluation design should reflect this. Naomi also observes that "the community of learners" is an "important simulation of scientific scholarship". Naomi’s comments serve as an important reminder of pedagogical principles which can often fall by the wayside in our concerns with the practical and technological aspects of online learning and for this reason I will quote her concluding paragraph in full:

"Therefore, to be graded, participation must be defined as a) learning procedure and/or b) examination procedure. What is to be learned must be articulated by the syllabus. How the learning of course objectives is examined will rarely receive a grade in itself, for it is the means to generate grades of performance for the topics discussed within it. At least, I have never heard of getting a grade for taking an exam. This leads to my final
point, which is that the means of assessment must be appropriate for the objective being assessed. Objectives of knowledge, of skill, and of disposition are not all measured easily nor equitably by the same procedure. This is a matter not of an online application of assessment methods, but of assessment literacy.” Naomi's point about making evaluation criteria explicit and transparent was echoed by José Maria.

Mark and others favour online discussion being "integrated into the mainstream of the course" and Janice gives the example of a module she runs where, although the discussion itself is not graded, there is a graded written work which can only be done from the discussion. David mentions that at the University of Paisley they award marks "based on the quality of the response to the discussion question" applying the PACE model (Sabin 2000). Apropos of this, Shane Dawson poses the question "Do you reward contributions made in face to face sessions whether lectures or tutorials?" while Bruce Jones asks "Is it good to apply behaviorist rewards and punishments to a constructivist environment?".

Jay Gould believes "online classes cannot be conducted without establishing a Code of Conduct" and proposes that a protocol could be drawn up based on the Loras College list of behaviors (http://depts.loras.edu/StudentDevelopment/PLI/web_resources/group_dynamics.html).

Deirdre Bonycastle's maxim "Start with the course goals/objectives/expected outcomes" echoes earlier words from Naomi Petersen and Deirdre goes on to illustrate how on one of her courses discussion-related skills were assigned 40% of the mark while on another only 5%.

Terry Andersen was kind enough to share with us some of his extensive work in this area which is due to be published shortly by Athabasca University in an Open Source book. He presents the useful concept of the online "teaching presence" and how it can be created and developed. He shares with us some current issues under debate in online teaching forums such as prescriptive assessment frameworks versus self-reflective assessment. The two detailed examples of the former are very interesting while the more learner-centred (and less time-consuming?) nature of the latter make it an attractive option for courses at graduate level as Brent Muirhead reinforces with his experience of students taking "personal ownership of their learning". Terry also mentions an ongoing debate around the acceptance of non-standard language in online postings by students.

Terry’s final paragraph summarizes a number of the ideas raised:

“In summary, giving directions for and modelling effective online discourse is a critical component of creating effective teaching presence. Assigning a portion of the assessment for the class to participation is a common practice in online learning courses. If participation is to be a formal and assessed requirement of the course, then developing and implementing an explicit assessment framework are essential, but potentially time consuming, teacher tasks. Some online learning teachers make this assessment into a more reflective task by assigning students the task of using their posting in the class conference as evidence of their understanding of content concepts and intellectual growth during the class. This type of assessed learning activity forces students to make quality contributions, and then to reflect on them. This strategy moves the locus of responsibility from the teacher to the student, a solution that can save teacher time while contributing to student understanding and metacognition.”

**Increasing and enhancing participation**

Mark Nichols reminds us that "rewarding participation with encouraging feedback works too" and he favors "participation through modeling" on the part of the facilitator and stresses the importance of modeling a responsive and reflective presence from the outset as "a shallow introduction earns a shallow response" .

From a pragmatic point of view, of course, many of us have to face the realities of institutions unwilling to pay for a tutor spending more than a minute or two per week per online participant. Bruce and others mention that facilitation online is a rather time consuming business and Janice goes one step further in questioning "whether a tutor needs to interact with a discussion (...)"; it is the students' discussion after all".

Steve Corich describes his experience as a participant in an assessed discussion where “it was clearly evident that course members who had English as their first language and who were used to open discussion were advantaged” and he suggests measures are need to address this.
Melissa Price, working in the UK, comments that "I found very early that students' previous educational experiences prepared them to be passive learners". I often hear similar comments about students in Portugal where I work and I recall a poster from India on this forum citing this as a major problem there. Melissa then describes how she has worked to motivate online students to become "intrinsic learners".

It would appear that passive learning strategies are perceived as a problem in a range of educational contexts. Bill Ellis compares graduate physics students in Edinburgh and those he encountered in the US and says he was "amazed at the lack of motivation (...) to learn" he noted with the latter; he puts this down to the methods used in the US K-12 second level system. Both Alfred Bork and Angel Medina tend to agree with this whereas Brent Muirhead believes that dedication in graduate work is a "variable that is difficult to accurately measure".

I noted a parallel between my observations and those of Deirdre and Melissa regarding very high levels of learner involvement which can result if collaborative learning tasks are appropriately designed. Angel Medina stresses the importance of cognitive aids and creating novelty in this process. At the same time, Ben makes the salutary observation that "tutor input can actually have a negative impact on student participation" and stresses the need for a "careful balance between silence (...) and saying too much".

Tracy Chao's question regarding how to encourage students to engage in dialogue rather than monologue in asynchronous discussion led Bruce Jones to suggest stipulating a word limit on contributions; Melissa favors a "gentle email" pointing out that long messages don't get read and distinguishing between "talking to the wall" and "talking with your fellow students".

Lorraine Wiseman believes that the VLEs she has used with secondary school students which allows them to participate synchronously online much as they would in an active classroom session (writing and drawing on whiteboard, intervening in discussion, going to break-out rooms to work in smaller groups) encouraged them to participate actively and made it easier for shy students than the F2F context.

On the other hand, Gaye Kelly, working with mature adults, notes the problems they may have in developing the confidence to express themselves "publicly" online and stresses that "the need to provide choice is critical (...) and we must allow for different learning styles and paces" as well as considering "alternative means of reflecting and evaluation". This last was borne out perhaps by Jenni Harding's experience where a learner on her course, although perceived by Jenni and others to make an important contribution to group-work, was the object of a complaint by another participant who believed she should not pass because she had not "finished" the stipulated activities. Mitch Weisburgh questioned 7 working graduate students in the 24-32 age group and found a consensus that being graded for discussion participation gave them the discipline to contribute regularly and that "the process of writing to the discussion group made them think through the points they were writing about".

Jon Dron mentions the problems arising on his course when students enter discussion late and find it hard to contribute effectively. Christie Mason refers to the perennial debate about alleged high drop-out rates in online courses and reminds us that most studies referring to this do not distinguish between dissatisfaction with the VLE and dissatisfaction with the learning process per se.

Others have commented on aspects of asynchronous work - Melissa noted that in a study she did in the early 90's, students tended to prefer a video of a lecture to attending it live because of the flexibility; Eric Flescher mentions the need for incubation in problem-solving.

Joe Griffin deals with the problem of "free riders" by including the "audit trail" provided by asynchronous discussion threads as part of the evaluation process for his Professional Issues course. Apart from the fact that the online nature of the course allows his students to collaborate with students from other universities he has found some evidence that "students who are involved in virtual learning groups do develop a greater level of moral reasoning than those who are in face to face groups."

Ludic Areas

Bruce has encountered student support for "informal areas of discussion" while Mark found "asynchronous chat more effective for social interaction".

From his experience, Ben describes how the "benefits to learning of increased social interaction were immense" and puts forward the idea of a "personal public space", similar perhaps to blogs. I believe the idea of
"homesteads" (a virtual house and yard which you decorate and fill as you please) used in some VLEs can perform a similar role.

Where to conclude this discussion?

This additional issue raised by Ben Hyde neatly brings home to us how the medium can influence the accessibility, quality and volume of participation. I very much appreciate the stalwart efforts from Ben in proposing, setting up and maintaining the parallel Ubiquitous-d3e site (http://ud3e.open.ac.uk/d3e_discussion.php?url=ifets.ieee.org%2Fdiscussions%2Fdiscuss_january2004.html&f=762). This has given us the opportunity to see the relative merits of an e-mail and web-based discussion around a document.

I would conclude by saying that although the questions posed in the pre-discussion paper do not by their nature lead to definitive responses, the sharing of ideas and practice from such a variety of educational contexts is invaluable in helping us to better define and develop our roles as educationalists.

References


Is it effective to use websites in getting parents involved in education?

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Discussion Schedule:
Discussion: 16-25 February 2004
Summing-up: 26-27 February 2004

Pre-Discussion Paper

Introduction

Parental involvement is an emerging issue in education. Many research studies show that when parents are interested in science and involved in science activities, their children’s performance in science increases. According to these research studies, many science educators are concerned with how to improve parents’ engagement in learning science. At the international science competition, U.S.A ranked lower than many Asian countries including Korea, Japan, and Taiwan (TIMSS, 1997). According to the report of TIMSS (2001), US eighth-graders performed slightly above the international average of 38 nations in science. In the 1995 study, US eighth-graders had tested above the international average in science, compared to students in 41 participating countries. Direct comparisons of international standing cannot be made between the two years because the list of participating countries is not identical. In fact, the data shows no absolute improvement in performance of US eighth-graders between 1995 and 1999, in science. To improve students’ performance in science, not only teachers at school but also parents at home must be engaged in science education.

Science teachers at schools want to get parents involved in science education. Even though science classes may be well prepared there will always be students who do not understand the material and think that science is a difficult subject. It is challenging for teachers with limited time and resources to successfully motivate all of their students to be excited about science. Individualizing the learning to each of the students needs can be an overwhelming task, but the individual support is critical to helping students enjoy science learning. Teachers realize that parents know their own children best and that when they are involved in the learning process both teacher and student benefit. One of the challenges is to develop productive ways to involve parents in their children’s learning.

Students who feel that science is boring and difficult could benefit from additional help and encouragement from their parents in studying science at home. When parents show interest in science and take part in science experiments related to what their children learn at school, the children may become more interested and excited about science. Not only is the home environment a great place for children to apply what they learn in school to their daily lives, but spending time with a parent who supports their child’s learning has effects that are immeasurable. Different from the school environment, home environments are the real places where students can make connections between book related facts and the real world. With the help of a parent, they can experience problem solving on a daily basis. In fact, the parent can help the child recognize a real-life problem and guide them in solving it. These kinds of experiences are ones that children remember forever.

Problems

Teachers and administrators who recognize the importance of parental involvement try to hold conferences and meetings with parents to further involve parents in science education. These meetings can be time consuming for the teacher and don’t usually engage the parents in doing science with their children. Additionally, there are many barriers that keep the level of parents’ participation in these conferences low. Some of the parent-centered barriers are lack of time, cultural or socioeconomic differences, language difference between parents and teachers, and parent attitudes about science and school. Similarly teacher-centered barriers include lack of time,
lack of training in working with parents, and teacher attitudes towards parents (Fehlig, 1996; Katz, 1996; U.S. Department of Education, 1997). There is a need to develop flexible strategies for increasing parent involvement with their children’s science education in the home.

According to the survey conducted through a nationally representative sample of 900 public schools enrolling kindergarten to eighth grade students, some of the barriers relate to the challenges and pressures that parents face and others are associated with the constraints facing teachers and other school staff.

According to the survey conducted through a nationally representative sample of 900 public schools enrolling kindergarten to eighth grade students, some of the barriers relate to the challenges and pressures that parents face and others are associated with the constraints facing teachers and other school staff.

![Fig.1 Percent of public elementary schools (K-8) that perceived various concerns as barriers to parent involvement at their school to a great or moderate extent](source)


### Solution

Because parental involvement provides an advantage of improving science education, it is necessary to address the problems that prevent parental involvement. Using technology as a tool for increasing parental involvement is a growing phenomenon in science education (Gergen, 1991). Technology not only provides a new way to communicate with parents but it provides a wealth of free and accessible resources that can easily be used by parents in the home. By engaging technologies in communicating with parents and supporting information about science education, teachers can overcome barriers to parent involvement in science education.

### Questions for subscribers to respond to

1. How do you think about getting parents (families) involved in education?
2. Have you ever involved parents (families) in your teaching?
   a. If so, what kind of technologies did you use in getting parents (families) involved in education?
   And what were the problems in getting parents (families) involved in education by using the technologies?
b. If not, what kind of technologies are you going to use in getting parents (families) involved in education? And what kinds of problems do you expect in getting parents (families) involved in education by using the technologies?

3. Do you think it is effective to use websites in getting parents (families) involved in education? Please elaborate your opinion explaining its advantages and disadvantages.

Reference


Post-discussion Summary

All the subscribers positively responded for the question 1 about parental involvement in education. Frank Egereonu (foe2001@COLUMBIA.EDU) provided literature on the merits of parental involvement: a series of publications developed by Anne Henderson and Nancy Berla: The Evidence Grows (1981); The Evidence Continues to Grow (1987); and A New Generation of Evidence: The Family Is Critical to Student Achievement (1995). According to the research studies, parent and family involvement increases students’ achievement and their school quality. To improve parental involvement, the research studies recommend that schools or programs for parents need to communicate frequently and effectively with parents or families (National PTA http://www.pta.org/parentinvolvement/standards/pfistand.asp#Research).

To communicate with parents frequently and effectively, it is one of good methods to use websites. Many responders agreed that school websites are good for getting parents involved in education. By using the school websites, parents can get information about their children’s educational progress in school and educational advices from school teachers at anytime and at anywhere. Yoon’s study with Korean parents was successful in getting parents involved in education through her school websites.

However, some teachers found that they have increased their work times beyond normal 8hrs a day. Since students and parents use the Internet as a tool for communication at anytime and at anyplace, they expect teachers will respond to their messages right away. Sometimes (like emergency), to provide fast feedback to parents and students, teachers need to be in front of their computers all day long. Richard Daddio said about the instances on Long Island. Parents on Long Island expect immediate feedback even during class time.

As a solution to the increased work time, Derek Chirnside suggested setting times for responding. Teachers schedule for their responding time and let students and their parents know the schedule. Then, students and their parents can know when they are going to have feedbacks from their teachers. Yoon recommended responding twice a day, morning and evening. That’s the way teachers can communicate with students and their parents frequently and effectively.

Yoon pointed out another problem found when she worked with parents who are economically low and lack educational backgrounds. It was so difficult for the parents to use websites as a communication tool. They did not have computers at home. So the school where their children go provided the parents the access to the school computer lab, but the parents could not find a time to use the computers because they needed to go out and work for living. Besides, they did not know how to use computers.
Frank Egereonu emphasized the cooperation between teachers and parents for the school website to be successful regardless of their economic situation. “The teachers need to be dedicated enough to provide information and materials necessary to keep the Web site up-to-date.” These materials can be in the form of homework assignments, projects, student-grades and schedules, etc. For parents, they need to have a time to appreciate school website and then, get more involved in it. Also, he added that schools need to provide parents computer training and access to computers before the communication starts.

Niall Watts provided very precious information for parental involvement in education by using websites. As a parent, she worked for making and updating a website for her child’s school. But she found it was difficult to keep updating websites because of other parents and teachers’ time and computer skills. Therefore, to get parents involved in education, it is necessary to train teachers and parents for developing computer skills. Professor Muhammad Betz includes developing websites with FrontPage as a part of syllabus for pre-service teachers.

According to Niall Watts, teachers and parents have time and energy in the evening to go online to check assignments, ask/answer, questions about homework etc. Therefore, if websites are well-updated and teachers and parents are well-trained, possibly parents get involved in education through websites.

Mitchell Weisburgh provided his successful experiences of getting parents involved in education by using websites. He ran a class website for a 5th to 6th grade class for two years. According to his experiences, to get parents involved in education, there are two things required: 1) make a lot of efforts in maintaining the website and 2) build website per class. Weisburgh took pictures of class events, posted schedules, ran various discussions, sent out reminders to parents, posted student projects, and went to school to pick the most current information. When the most current information and pictures were on the website, parents liked to go to web. Also, he found out that when one website was developed for one class, the same group of kids could stay together and their parents had one place where they could get the information directly related to their kids at school, so that parents got successfully involved in education through the class website. But as Weisburgh mentioned, to maintain the website, it requires long time and efforts. He, as an expert, took 10hrs a month to keep up the site and also worked a lot for making the site interesting.

Frank Egereonu pointed out the maintaining issue again to successfully get parents (especially male parents) involved in education. According to Egereonu, female parents tend to communicate more by e-mail than males do. However, male parents are more active at Internet usage like game-playing. Yoon’s study with parents also supports Egereonu’s idea. Yoon talked with mothers over the Internet but not with a father when she studied with parents. Therefore, to get male parents involved in education, it is necessary to make the site interesting. Yoon suggests a cyber café for chatting where people can select their animated images that represent them to talk. The animated image talks to the other image whenever people type their messages in a chat room. With the program, male parents can feel like they play a game, chatting with others face to face, thus actively participating in communication.

Another way to get parents successfully involved in education by using website is to give computers to them (Frank Egereonu). Lack of time is one of the obstacles to parental involvement. A lot of parents may not have the time to visit the school computer. Therefore, when they have computers at home, it can mitigate the time barrier to parental involvement. The successful stories about making people involved in educational websites by providing computers can be found in many studies. Most parents had computers at home when Watts worked for developing a school website and communicated with others through the website. Also, Yoon’s study with Korean parents showed that all of them had computers at home and the study with them to get parents involved in education was successful. Frank Egereonu pointed out that one of the reasons why parental involvement in America is not successful is lack of computers at home. “In a typical public school in the USA, a majority of the families do not have a computer at home. This has been said to be the main reason why a school Web site may not be an effective home-school communication tool.” Only by having computers at home, parents can not be involved in education but having computers at home or near at home makes possibility bigger to get parents involved in education through websites.

Besides of providing computers, it works more effectively to use websites for parental involvement in education when schools make events where parents need to participate. According to Mitchell Weisburgh, when he maintained the class websites, the class made events, like exhibitions and meetings. So, parents had 10 times during the year they were expected to be in school, in addition to helping out on the exhibits. That’s the way parents go to school and see how their children learn in the school and meet teachers face to face. Then, they have more passion to contact school frequently which brings parents to the website.
Overall Summary and Reflection

Everybody knows that when parents and families involve in education, their children’s performance in school and their school’s quality increase. But because of time, parents cannot frequently participate in education. To mitigate the barrier to parental involvement, the subscribers provided suggestions:

1. Schools or programs need to provide interesting and well-maintained class websites (or small size websites);
2. Schools or programs need to provide access to computers (or computers) and training for computer skills.
3. Schools need to make events where parents need to participate. That’s the way parents and teachers can make cooperation among them.

Even though parents are busy making money for living during daytimes, they can make a time during night for checking websites if schools provide websites that parents want to use. Therefore, schools need to make more efforts to improve educational websites that parents can get involved in.

For future discussions

Georgia pointed out that parents play a very important role to improve the educational outcomes of their children. But to do educational improvement in their children’s performance, he suggested sanctions and monitoring family behavior. But the question is in what form those sanctions could realize and how the monitoring of families could stand up against the privacy rights.

To his question, Yoon provided her experience with Korean parents. Jiyoon monitored parents’ behavior by interviewing based on questions that she prepared. The Korean parents who signed up for the study liked to be monitored regularly with the researcher. By on-line chatting or discussing, parents’ behaviors can be monitored and if web-cameras are added, it is better to monitor parents’ behavior. But the forms of sanctions are still questionable.
Remarks on the Variety and Significance of Advanced Learning Technologies

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Abstract
This paper provides a reflective overview of the eight papers collected in this special issue of Educational, Technology and Society that is based on ICALT-2003. We provide a very brief description of the conference and then discuss the eight papers in the context of a focus on learning and a focus on systems. In the conclusion, we offer our thoughts on the notion of borderless research and development, the inseparability of the different aspects of learning and instruction, and likely trends and innovations.

Keywords
Advanced learning technology, Authentic learning, Collaborative learning, Learning objects, Metadata, Problem-centered learning

Introduction

The third IEEE International Conference on Advanced Learning Technologies (ICALT) was held in Athens, Greece in July 2003. There were 337 submissions to that conference. The acceptance rate for full papers was 14%; for short papers the acceptance rate was 28%. There were 145 papers published in the proceedings for that meeting along with descriptions of 56 poster, 4 workshop and 4 panel sessions (Devedzic, Spector, Sampson & Kinshuk, 2003).

The conference was richly international at every level. The conference chairs represented Greece and New Zealand. The program chairs represented Serbia-Montenegro and the USA. The steering committee included representatives from the Finland, Greece, Japan, The Netherlands, New Zealand, Russia, the UK, and the USA. Keynote speakers represented North America and Europe. Papers came from every region of the world and...
represented a rich variety of perspectives and activities. The focus of the conference was on design and development issues involving advanced learning technologies. Topics covered included architectures for learning systems, artificial intelligence applications, collaborative learning, distance learning, instructional design issues, integrated learning environments, learning communities, learning objects, metadata, pedagogies, virtual reality and much more.

The organizing committee (Sampson, Kinshuk, Devedzic & Spector) selected 8 of these papers to be further elaborated and refined for publication in this special issue of Education, Technology and Society. The selection of these papers was based on several criteria, including innovation, quality and representation. Obviously much excellent work presented at the conference at the conference is not represented here. It is our hope that readers of this special issue will then seek out the larger Proceedings (Devedzic et al., 2003) and pursue other work presented in Athens. As the program co-chairs and reviewers of these papers, we offer in what follows our reflective comments on this selected collection of research and development in the area of advanced learning technologies.

Discussion

It is difficult to categorize these papers as belonging to any one of the themes or topic areas indicated earlier. This difficulty will be addressed in our concluding remarks. For the sake of the discussion, we will comment on these papers in terms of issues involving learners and issues involving systems. We recognize that these are somewhat arbitrary categories and that nearly all of the papers make comments about both learners and systems.

Focusing on learners

What do these papers have to say about advanced learning technologies in terms of learners? Several papers address innovative uses of technology in school-based settings. Morozov, Tanakov & Bystrov (this issue) examine the use of pedagogical agents in science classes for children between the ages of 10 and 12. The authors implemented an authoring environment called NATURA that allows for the creation of rich and realistic multi-media environments and promotes active learning about science from a child’s perspective. The authoring framework is apparently cost-effective, powerful and easy to use. More significant, however, is the perspective assumed in generating learning environments. NATURA encourages authors to assume the child’s point of view in learning about science as the users – children – are asked to assume roles in game-like activities organized for the purpose of discovering or uncovering various scientific principles. What is especially notable in NATURA is that the instructional design principle to emphasize or integrate authentic or real-world problem-solving activities is interpreted from the child’s perspective (Brown, Collins, & Duguid, 1989; Bruner, 1986). The assumption behind this learning environment is that it is the child’s real world that should be integrated into active learning.

The paper by Kravčík, Kaibel, Specht & Terrenghi (this issue) reports on a project that involves a mobile form of e-learning intended to support students on field trips (RAFT). Whereas NATURA is aimed at enhancing or enlarging or extending a classroom by allowing for rich multi-media experiences, RAFT assumes that children leave the classroom on occasion to explore and investigate the world around them. RAFT provides the means to collect data, capture digital photographs and audio, and take and organize notes. The authors report that RAFT is easily learned and that the users – children between the ages of 10 and 14 – found RAFT useful and were able to create rich and well-organized reports of field trips. Motivating learners is a recurrent theme and is obviously important to learning effectiveness (Keller, 1983). This paper adds the notion that learners want to encounter the real world and can be actively involved in these experiences using tools and technologies that can be carried back into classroom activities.

The paper by Avouris, Komis, Margaritis & Fiotakis (this issue) focuses on an environment to study collaborative learning, which has receive much attention in the educational research community in recent years (Dillenbourg, 1999; Salomon, 1993). The authors rightly recognize that while there has been much attention devoted to collaborative learning there is rather sparse empirical evidence describing outcomes on which to base prescriptions for the planning and implementation of effective learning environments. The activity analysis tool and the collaboration analysis tool represent important contributions towards evidence-based research and development in learning and instruction. The relevant instructional design principle involved in such efforts can be called WYMIWYG (pronounced ‘whim-ee-whig’), which stands for “What you measure is what you get” (Spector, 2001). If teachers do not assess learning outcomes, then they do not know what learning progress is
occurring. If developers do not evaluate systems, then they do not know whether, how or why the learning environments they create are effective.

A particularly important kind of measurement important to learners, teachers, designers and developers involves the determination of a problem’s difficulty. Many learning environments are now problem centered (Merrill, 2002; Seel, 2003). One problem with regard to problem-centered learning and instruction is knowing which problems to present to which learners in different situations. Making this determination involves knowing the relative difficulty of various alternative problems that could be presented. The paper by Kuo, Lien, Chang and Heh (this issue) addresses this issue directly and offers a methodology based on the use of neural networks and knowledge maps. The authors report evidence that their methodology, which is based on a four-step problem-solving strategy (identification, elaboration, planning and execution), works and can be used in the context of an intelligent tutoring environment and other contexts. The assumption behind this work is that learners naturally perceive problems to be of differing difficulty and that the determination of the relative or perceived difficulty of a problem should be learner-centered rather than problem-centered [the authors do not state this principle explicitly but we believe that is consistent with their findings].

**Focusing on systems**

What do these papers have to say about advanced learning technologies in terms of systems? The topic of learning objects was much discussed at the conference and is a central topic for instructional technologists (Wiley, 2000). Two papers in this collection focused on the use and implementation of learning objects in peer-to-peer network-based instructional systems. The paper by Qu and Nejdl (this issue) reported on the Edutella open source project that aims to exchange metadata based Resource Description Frameworks (RDF) from one repository to another. The learner is in the background in this discussion as someone who will benefit from the reusability of learning objects in one setting and residing in distant data repository by gaining access to those objects in a local repository. Erik Duval, one of the conference keynote speakers also addressed the importance of standards for learning objects that cross network and other boundaries, echoing the centrality of the technical challenges associated with designing, developing, implementing and managing reusable, accessible, and customizable learning objects to support a variety of learners distributed in a variety of settings and situations. The Edutella project transforms SCORM XML metadata into a standard form that can support exchanges across learning object repositories. This is an important technical step in providing the basis for globally usable local learning objects.

The paper by Brase and Painter (this issue) is also aimed at improving reusability and retrievability of learning objects. These authors describe an inference engine based on Prolog for the generation of metadata when none exist. The engine queries course descriptions and uses a semantic network to create meaningful metadata to support reuse of learning objects. This effort was based on the Dublin Core set of 15 basic metadata elements. It should be obvious that metadata generated by such a system is ultimately on human descriptions (e.g., the course description). A learning environment could be designed with all metadata tags in place and still not promote reusability if the tags do not contain correct, relevant and meaningful information. The limits to automatically generating metadata for existing learning environments and instructional systems remains a largely unexplored and highly challenging area of investigation.

The paper by Hadjileontiadou, Nikolaidou, Hadjileontiadis, and Balafoutas (this issue) is aimed at promoting online collaboration using a fuzzy logic inference system to extend the capabilities of another system called Lin2k. As mentioned in the previous section, collaboration is an important topic for educational researchers and collaboration at a distance is a particular challenge for learners. This system dynamically adjusts to user collaborations and creates pre-structured interfaces for the next anticipated interaction between collaborators. Evidence suggests that this kind of pre-structuring support helps keep the collaboration on task and on track but does not overly constrain a user who may select a new or unanticipated action and thereby change the dynamic model of that collaboration. The authors report that the cost of extending Link2k in this way was relatively minor, and they suggest the new system could generalize to support a wide variety of collaborative efforts. Of course the evidence will ultimately decide the issues of cost-effectiveness and generalizability.

The paper by Taurisson and Tchounikine (this issue) describes an application of artificial intelligence in the area of learning communities. Support for the developing and sustaining activities of communities of practice is of central concern to educational technology researchers (Steeples & Jones, 2002; Wenger, McDermott & Snyder, 2002). We mention the paper by Taurisson and Tchounikine here rather than in the section focusing on learners because the focus is on the scalable implementation of software agents to support learning communities. The
agent framework is based on an activity system (Engeström, 1987) and has been tested with university computer science students. It will be important to find out if such an approach works as well for English majors, school children and adult workers. In any event, we have included this paper because it represents an important extension of technology into group-based activities that may or may not be organized around schools and classrooms. Indeed, one might see such systems eroding the traditional distinction between learning and working.

Concluding Remarks

Several things stand out in these papers. We mention three areas as particularly pertinent to the likely future of advanced learning technologies.

Research and Development without Borders

Progress in this and many other areas of science and technology is likely to be improved when research and development proceed with minimal interference of artificial barriers and borders. As already mentioned, the conference brought together people form all parts of the world with richly divergent views. Areas of complementary work were identified and extended collaborations are underway as a result. This is a general benefit of international meetings and publications. In our case, we happen to be concerned with technologies aimed at enhancing this kind of global intellectual networking. As a community of professional practitioners, we ought to be using the same technologies we advocate in support of learning and instruction to enhance our own work. We all benefit when we can move in a facile way across traditional institutional, cultural, national and other barriers. In an important sense, the technologies discussed in this special issue of Education, Technology and Society – e-collaboration, metadata, mobile technologies, software agents, etc. – represent an important aspect of the future of society. Can we use these technologies for the benefit of all or will we continue to grow apart?

Inseparability of Issues

We arbitrarily put the papers into two categories – those focusing on learners and those focusing on systems. However, a theme that emerged at the conference, that is echoed in the papers and that is hopefully evident in our discussion is that the topics treated are not really separable. One cannot ultimately separate learners from systems just as one cannot separate an interface from a user or collaborative support from collaborators. What is becoming more evident as we explore advanced learning technologies is that holistic and systemic views of learners and their environments are necessary if we wish to make progress (Spector & Anderson, 2000).

Innovations and Trends

What can we say about the future of advanced learning technologies? If the future happens to resemble the past, then we can say with a fair amount of confidence that it will likely bring changes that we do not now envision. Nonetheless, tools and technologies to support distributed learners are likely to become more sophisticated and more prevalent, further eroding the traditional boundaries between learning and working in some cases. It is likely that standards to realize the potential of reusable learning objects will emerge and that tools will become more transparent and pervasive. The focus on learners appears well established in principle, but the practice of taking learners for what they are and as they are has yet to catch up. This is partly due to the view of many educators who believe the correct role of education is to transform, since learning is fundamentally about change.

What is not clear at this point is who will determine the nature of desired transformations. One might hope that it would be those directly affected by the transformation – namely, learners. What is not clear for us in the midst of these impressive innovations and the rapid advance of educational technology is what will become of the roles of learners and teachers. The popular adage that the role of the teacher is being transformed from that of a sage on a stage to a guide on the side does not appear accurate today, nor is it evident that teachers should always and only be guides as opposed to sages.
While we have learned much about learning and instruction on account of new technologies, there is much that we do not know. Moreover, it is important to retain a humble attitude with regard to the technologies that we help to create. The basic question in our work is this: What will come from we are doing and are likely to do in the next few years? The basic answer is that we do not know. We hope that we can contribute to the personal and intellectual growth of others and help people better understand their worlds.

References


A Team of Pedagogical Agents in Multimedia Environment for Children

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Abstract
This paper presents the multimedia product for teaching Natural Sciences to 10-12 years old children. In this product three pedagogical agents, Teacher and two pupils guide the learner through the virtual environment. The inclusion of a team of pedagogical agents permits us to create a micro-model of lesson activity and gives a reliable support of individual learner differences. The script-based approach is used for creating the rich multimedia content of this product. Scripting object-oriented language NML and authoring environment NATURA is described.

Keywords
Virtual learning environment, Pedagogical agents, Scripting language, Authoring environment

Introduction
The rapidly growing number of instructional multimedia software is accompanied by increasing research in new forms of multimedia presentation and interactivity.

One of the modern and progressive techniques in Human-Computer Interface design is the application of interface agents – on-screen animated characters. Interface agents enable computer interfaces to become more human or more “social” (Hermans, 1997). In educational software the interface agents have become for pupils not only the conductors in the new computer world but they have also started giving educational information fulfilling the functions of teachers (Nijholt, 2001).

This new form of educational programs is especially good for schoolchildren as it provides a high level of motivation and gives the possibility to realize active forms of training (Lester at al., 1997).

In this article we go through the multimedia educational system for the school course in Natural Sciences. The system was developed at Multimedia System Laboratory at Mari State Technical University. Three animated characters – Tatyana Mikhailovna, a teacher, and her two pupils, Masha and Petia, are setting off in a virtual travel to wonderful islands to study some basic physical and chemical concepts and phenomena. For realization of the multimedia educational product on Natural Sciences we worked out a special authority program environment called NATURA and the language NML for script writing. All these are described in Section 3.

Pedagogical agents in the virtual world of natural sciences

Appearance of animated human-like characters as the interface agents is the logical step in evolution of graphic user interfaces. It is caused by the fact that the use of the agent technology transforms human-machine interaction into a “face to face” dialogue, where an interface agent provides the information exchange (Huang, 1999).
Interface agents in educational environments are called the pedagogical agents. These agents usually have enough understanding of the educational context in order to be able to play certain roles in education scenario and interact with learners during the education course (Shaw, 1999).

Pedagogical agents are also used to create effective educational software for children. Besides the afore mentioned advantages of using the agents for providing learning materials to the kids, the application of animated human-like characters allows the creation of an educational environment similar to computer games. It helps to stimulate children’s interest in utilizing such a program and therefore it can add motivational value to learning.

All these potential benefits associated with pedagogical agents were the reasons to include the animated characters in the concept of the multimedia software for teaching Natural Sciences to 10-12 years old children. The new form of multimedia presentation allows us to create an effective educational environment for learners to be able to grasp and retain some of the fundamental concepts of Physics and Chemistry.

When choosing the proper character for the role of the pedagogical agent, many factors are to be taken into account, including pedagogical functions of this agent, a target audience and an educational content of courseware (Moreno, 2000).

Presentation and explanations are considered to be the major functions of the pedagogical agent in this project. It is obvious that the agent acting alone as a Teacher would perfectly perform those functions. A traditional monologue lecture format however is not appropriate for pupils of primary school age who are mentally, socially and emotionally ready for much more vivid and lively forms of teaching. The transition to a learning environment with a team of pedagogical agents is more suitable in this instance.

For several centuries the teaching method has been known as the Socratic dialog. It is used for conversations between Teacher and Learners in order to discover the truth. The form of such dialogues has also been applied to explain complex concepts and theories. It was Giordano Bruno, Galileo Galilei and Voltaire who cast their works in the dialogue form. At present, in the modern e-learning systems, the “Socratic” method of teaching is employed to help the students better understand and learn from the course content. It is also important to note that the dialogues and discussions, not only between teacher and learner but also among learners are essential parts of a traditional classroom activity.

For these reasons an agent ‘learner’ makes an appearance alongside the agent ‘teacher’ in virtual world of educational software. The agent ‘learner’ can put questions to the teacher, listen to his answers and then answer questions from the agent ‘teacher’. However the communications between a teacher and only one pupil cannot reproduce the whole social-psychological context of a real educational environment. For this purpose the communication formula “a teacher and two pupils (a boy and a girl)” is more appropriate.

Therefore, three autonomous pedagogical agents named Tatyana Mikhailovna (a teacher), Masha (a girl, a brilliant pupil) and Petya (a boy, an inquisitive and creative child) (Figure 1) act in this virtual educational environment.

The inclusion of such a team of pedagogical agents permits us to resolve the following problems:

- Create a micro-model of lesson activity - child's customary environment.
- Improve the opportunities for dramatizing agent dialogues.
- Give a reliable support of individual learner differences.

Besides, the functions of interaction with the virtual world objects are assigned on the pedagogical agents for the purposes of the investigation and demonstration of physical processes.

**Software implementation of the multimedia course**

Powerful software tools are required for the development of the learning environment with numerous different media objects and life-like characters. Modern computer game engines possess such capabilities for presentation. However there are financial restrictions on employment of those engines for development educational software. It should be noted that VRML often used for educational purposes does not have enough expressive power for multimedia learning environments with pedagogical agents. Therefore a new, technology–effective and
functionally rich authoring environment, has been designed to create the multimedia software for Natural Sciences teaching.

![Figure 1. Pedagogical agents in multimedia Natural Sciences](image)

**Using scripts to create complex multimedia system**

Using internal scripting language is the best way to create computer games and educational multimedia software, which combines 2D-graphics and real-time 3D animation. Main advantage of scripts is to define accurately all multimedia presentation details (visual appearance and spatial location of the graphical elements, temporal synchronization of media-components, interactivity). In addition to this, the preparation of interactive presentation is separated from development of the visualization software. It can simplify the process of creating rich multimedia content presented via a wide range of media components and their integrated forms.

Taking into account, an authoring environment NATURA has been designed to create the multimedia product for Natural Sciences teaching. The NATURA comprises a rendering engine and tools for preparing multimedia data and script of their presentation.

In the authoring environment the script is written in a specially developed NML language (NATURA Multimedia Language) and translated into binary code by a translator for more effective use. The presentation model is a hierarchical structure consisting of scenes, multimedia objects and their compositions. (Figure 2)

![Figure 2. The multimedia objects hierarchy in NML](image)
The description of multimedia presentation in NML language is performed in the following order. The constants are defined in the beginning of the script then follow the templates of multimedia objects, compositions and scenes. Next, the scenes themselves are described. Each scene gets its name and the description of the multimedia objects, compositions and events. The list of basic multimedia objects used in NML is given in Table 1.

### Table 1. Multimedia objects in NML

<table>
<thead>
<tr>
<th>Multimedia Object</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Image</td>
<td>Static graphics</td>
</tr>
<tr>
<td>Anim</td>
<td>Animation</td>
</tr>
<tr>
<td>Audio</td>
<td>Sound</td>
</tr>
<tr>
<td>Video</td>
<td>Video clip</td>
</tr>
<tr>
<td>Html</td>
<td>HTML-document</td>
</tr>
<tr>
<td>Object3d</td>
<td>Mesh based 3D object</td>
</tr>
<tr>
<td>Motion</td>
<td>3D object motion</td>
</tr>
<tr>
<td>Speech</td>
<td>Speech of 3D character</td>
</tr>
<tr>
<td>Camera</td>
<td>Camera in 3D-world</td>
</tr>
<tr>
<td>Light</td>
<td>Lighting</td>
</tr>
</tbody>
</table>

**NATURA Engine**

NATURA engine renders multimedia objects. The engine includes several modules (managers): Application Manager, Scene Manager, Render Manager, Sound Manager and Resource Manager. The structural diagram of the NATURA engine is given in Figure 3.

The NATURA engine works as follows. The Application Manager initializes graphical libraries, creates the main window, initialises another managers and passes the control to the Scene Manager. The Scene Manager loads the script of a starting scene, runs threads for loading multimedia objects and initializes them. Next, the control is transferred to the Render Manager that requests the list of visible elements from the Scene Manager, combines them and displays the result on the screen. While a presentation is played, graphical dynamic multimedia elements can send the messages about the necessity of updating its image to the Render Manager. Render Manager, in turn, requests from the Scene Manager the list of all graphical elements intersected with this element and displays their union on the screen.

![Figure 3. The structure diagram of the NATURA engine](image-url)
When the “go” command is executed the Scene Manager pauses the Render Manager and Sound Manager, and then removes from memory an old scene and all its multimedia objects. Next, a new scene and all its multimedia objects are loaded and initialized. The Render Manager and Scene Manager then resume their execution.

**Interactive multimedia natural sciences software for children**

The rich possibility of the developed authoring environment allowed us to create intriguing learning software. Pedagogical agents, a teacher Tatyana Mikhailovna and her pupils Masha and Petya, are taking a walk through the virtual islands "Matter", "Forces" and "Physical phenomena". They can go to the forest, to the park, to the stadium, to the beach and to many other places where they can learn many new and interesting things about basic physical and chemical concepts and phenomena.

Various forms are used for the presentation of learning materials in this multimedia software. The agents-pupils do not just listen to the teacher and ask her questions, they also interact with the objects in a scene for the demonstration of physical science phenomena. For example, in the lesson on the concepts of friction, Petya goes down from the children’s slide, roller-skates in the park and attempts to shift a car manually. When Newton’s laws are studied, Petya and Masha ride bumper cars. Furthermore, a set of learning exercises with game-like interactivity is also incorporated into this learning environment. So children are performing interactive exercises and the pedagogical agents are assisting them during this process.

**Figure 4.** Petya and Masha are studying Newton’s laws

**Conclusion**

For years advanced forms of multimedia (real-time 3D characters, virtual reality) have been used in the computer game industry with excellent results. Now they are starting to be adopted in the Computer Based Learning industry. However many efforts will be needed to realize new potentialities and possibilities for creating educational multimedia software which is not only engaging, but also effective. The interactive multimedia Natural Sciences software for children and authoring engine NATURA presented in this paper are one of the steps on the way to new generation of multimedia learning system.

**References**


Mobile Collector for Field Trips

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Abstract
Current e-Learning is based on learning management systems that provide certain standard services - course
authoring and delivery, tutoring, administration and collaboration facilities. Rapid development of mobile
technologies opens a new area of m-Learning to enhance the current educational opportunities. Field trips
are a relevant part of the curriculum, but for various reasons it is often difficult to organize them. The aim
of the RAFT project is development of a system that would enable virtual field trips. One mobile learning
application prototype created in this project, called Mobile Collector, enables data gathering and annotation
in the field, together with real time collaboration. The application supports learner-centred education in real
world context.

Keywords
Collaborative learning, Constructivism, Mobile learning application, Virtual field trips

Introduction
Modern e-Learning is based on the Internet infrastructure, hypermedia technology, advanced graphical user
interface, sophisticated communication and cooperation services. Standard formats enable interoperability and
reusability of resources, searching is supported by means of metadata. Instead of the traditional behaviouristic
approach in education more attention is given to cognitivism and constructivism. Learning management systems
represent the main platform for e-Learning providing various facilities (Maurer, 2002):

- Courseware modules - reusable, searchable, interactive, and customisable
- Authoring tools - to create and combine the modules
- Administration tools - to manage these modules and their users, to provide statistical data about them
- Tutoring tools - to provide overview on the progress of a class as well as each individual learner separately
- Communication and cooperation tools - with automatic notification, searching and filtering facilities
- Support for various learning models and styles, on different cognitive and knowledge level

Current learning management systems usually include most of these components, but they are still not adaptive
enough, taking into account the student’s preferences, knowledge, learning styles, objectives, interests, and other
attributes. Therefore the current trend is to provide personalized adaptive learning in open and distributed
environments.

Nowadays we can see a rapid development of mobile information technologies. The range of ubiquitous services
is growing. Mobile systems have the potential to influence also the area of education in the near future, as they
are especially popular among young people. Therefore it is a challenge for developers to offer new mobile
applications that will together with entertainment provide also innovative learning opportunities. We cannot
expect that m-Learning will soon substitute e-Learning as we know it today. There is still no real reason to omit
powerful desktops with large screens. One should rather see mobile solutions as enhancements of the current
educational technologies. We see several important new issues for mobile learning:

- “Develop-once deliver-many” idea as new authoring tools for learning content enable the authors to deliver
  their content in a variety of formats
- Contextualized information, delivered adapted to the current user context, where the context may include the
  personal preferences, the current task, the location, and the time (Abowd, Day, Abowd, Orr, Brotherton,
  1997; Gross, Specht, 2002)
Modern education technologies can drive the development process in the area of pedagogy. As pointed out for instance by B. Trilling (PILOTed, 2004), our existing school system is well designed and adapted to the industrial age, when people mostly worked on manufacturing processes in a routine way. In the knowledge age the goal is to get people into the higher skilled, knowledge work jobs, demanding critical thinking, creativity, collaboration and interpretation abilities. To support the experiential and active learning (Kolb, 1984) teachers embed field trips in the curriculum. But it is often very difficult to organize meaningful field trips for various reasons, including finance, staffing levels, health and safety issues. In this area appropriate use of technology can improve and enhance educational experience of students.

The developments in wireless communication and mobile devices, the pedagogical demands for cultivating knowledge management skills and existing difficulties with organization of field trips led us and our partners in the consortium to initiate the RAFT (Remote Accessible Field Trips) project. Its philosophy is the employment of the available technology to produce an integrated and interactive system for linking, in real-time, field trips and classrooms. According to the RAFT approach only a few students go to the field and the remaining students interact in real-time with them. This should be achieved by means of web based tools, designed according to the collaborative learning principles.

The design of new applications that allow the integration of mobile interface and mobile learning processes is currently a hot topic of discussion. For example the KLEOS project looks at the temporal arrangement of learning episodes and individual learning projects, combining those with the spatial and semantic dimension of learning content and context (Giasemi, Vavoula, 2002). In most of the recent works on mobile learning, problems concerning efficiency and simplicity of use are usually mentioned. This is due to the typical constraints that have to be considered in mobile computing generally (small screens, input/output constraints, limited power and connection supply, situation of use on the fly) together with the specific issues raised by the learning objectives (the cognitive status of users, pedagogic goals of situated learning and collaborative work).

In this paper we explain the approaches of the RAFT project to augment the learning experience and then present our Mobile Collector for data gathering in real world contexts and remote collaboration, describing its functionality, design, and evaluation. Finally we provide concluding remarks and outline further development of the RAFT system.

Remote Accessible Field Trips

The RAFT project (RAFT, 2003) aims to support students in active, cooperative and sustainable learning combining classroom and on-site research. The main scientific and technological objectives of this project are to demonstrate the educational benefits and technical feasibility of remote field trips, to establish extensions on current learning material standards and exchange formats for contextualisation of learning material. This is combined with the embedding of learning and teaching activities in an authentic real world context, with real time video conferencing and audio communication to promote new forms of contextualised learner collaboration.

Investigations into the current state of field trips and the curricula in various countries show that despite the recognized educational benefits there are many limiting factors such as time in the curriculum, consent, health and safety factors, insurance and staffing. Virtual field trips provide the next best thing to actually being in the field. However, problems occur when students need personal contact with their teachers (Frank, Reich, Humphreys, 2003). The RAFT approach is to help alleviate this problem by allowing opportunities for constant communication between students and teachers.

The success of the system will depend on its educational and curricular relevance. Therefore the RAFT field trips are being developed in cooperation with practising teachers is a wide area of subjects. The learning theories most appropriate to the RAFT approach, as they consider learning as a social activity, are based on Piagetian and Vygotskian concepts. They include:

- Collaborative learning: working with peers in the classroom and in the field as well as with students from other schools or countries towards a common outcome
- Cooperative learning: a group solves a task, each member contributes to achieve the joint result (Johnston, Johnston, 1994)
- Situated learning: learning in an authentic context, practical problems are solved (Lave, Wenger, 1991)
Peer assisted learning: two students work together for their group (Topping, Ehly, 1998)
Vicarious learning: “meta-learning” learning by observing other groups’ approaches (Lee, Dineen, McKendree, Mayes, 1999)

A key objective of the RAFT project is to enable all the participating students to be involved in the learning experience. Therefore a cooperative approach to learning has been adopted. Each student has a particular role in a group and each role has a specific task. The scope of these roles is being investigated, including the qualities developed in the pupils taking these roles (Rentoul, Hine, Specht, Kravcik, 2003).

The engineering of the RAFT client devices includes the authoring toolkit for creating contextualised learning materials, the mobile reader client for the replay of contextualised learning materials, the mobile field station for the coordination of several mobile clients, and the extension of the learning management system (LMS) for managing scheduled live interaction between remote field trip clients and classroom students. The RAFT system will integrate the LMS with customized solutions for contextualised live interaction and video conferencing. The design and implementation of different interface components for interaction with the LMS from PDA, wearable computer and the integration of live video and audio conferencing templates are the main tasks. Additionally the currently implemented metadata sets should be extended for capturing and handling additional context data about learning objects. Different functions of the proposed system in three layers (operating, servicing and enabling) are shown in Figure 1.

![Figure 1: Functional Overview of the RAFT System](image_url)

The Learning Services in the diagram are represented by the system called Adaptive Learning Environment (ALE) that has been originally developed in the WINDS project (WINDS, 2003). The system combines the functionality of an e-Learning system with adaptive educational hypermedia on the Web (Specht, Kravcik, Pesin, Klemke, 2001; Specht, Kravcik, Klemke, Pesin, Hüttenthal, 2002). In the RAFT project (RAFT, 2003) we develop ALE further so that it can support also mobile learning (Kravcik, Specht, Pesin, 2002; Kravcik, Specht, Kaibel, Terrenghi, 2003).

**Mobile Collector**

The basic principle of our approach is simplicity and usability regarding both data collection and annotation. As a part of a course the teacher can prepare a learning object called *field trip* which consists of several modules called *topics*. Each topic includes several *tasks* for the learners in the field. For every task a learner (or a group of learners) creates one (or more) *collection(s)* where collected photos will be placed. The pupils in the field can collect data, annotate it, and assign related metadata to it. The data is stored in such a way that later on it can be
easily retrieved when needed. There is a communication channel between the field and the classroom so the
learners in the school can ask questions, give suggestions to their peers outside, or help them providing useful
information on demand. The Mobile Collector application should meet the following demands:

- Authoring: simple creation of learning objects related to field trips
- Data collection: possibility to collect data (especially photos) in the field and to store them into a common
  repository
- Data annotation: possibility to annotate (both by predefined concepts and audio) the collected data in the
  field in an easy way
- Data retrieval: possibility to navigate and search for the collected data so that it can be reused
- Learning objects elaboration: possibility to integrate the collected data into structured learning objects
- Protection of author rights: students can edit or delete only their own data, but they can view also the data
  created by their peers

Learners can capture photos directly in Mobile Collector and if they are satisfied with it they can store it into a
suitable collection. The photos can be annotated directly in the field. To make the annotation process as simple
as possible the learners just choose appropriate concepts (keywords) from a list predefined by the teacher.
Additionally they can create audio annotations for the collected photos. All the users (teachers and learners) can
easily find a collection of a particular learner (or group of learners) for a certain task and also all the photos
associated with a particular concept. All the collected data is stored in the ALE repository and can be later
elaborated by the learner as well as evaluated by the teacher. All these materials are searchable and can be used
to produce flexible and reusable learning objects. In this way the learners can integrate those materials into their
projects and the teachers into their courses.

In the field learners can use various types of mobile devices for collecting data. The choice depends on the
objective of the particular field trip and on the available equipment. Our Mobile Collector can run on devices
that can browse the Web, have access to the ALE system, render Java applets, are equipped with a camera and a
microphone. The synchronous communication channel is not a part of this application and can be provided by
means of third party chat or videoconferencing systems (FlashMeeting, 2003), alternatively also by mobile
phones. From the demands specified earlier these technical requirements can be derived:

- Mobile Collector devices must be easy to carry, easy to handle, and independent from external power supply
- Data transmission must be real-time (to enable real-time remote collaboration)
- Data transmission should require as little bandwidth as possible (to enable the use of Mobile Collector in
  environments where wireless communication with only narrow bandwidth is available)

Design

In RAFT we support the idea that each role can perform specific functionalities and needs therefore a specific
interface and device. This issue is even more relevant if we consider the target group, which is not necessarily
accustomed with technology and should be supported in the learning activity rather than be overwhelmed with
complexity. Beside the specific tasks of a role, additional factors affect the design of the application and of the
user interfaces:

- Complexity of the device: a user who has to concentrate on annotation in the field needs a support for this
  activity and requires the device to be light and portable
- Complexity of the task: a user collecting data is already quite busy and most of her senses have to contribute
to the task; in the meanwhile she has to be able to experience what is happening in the surrounding
- Complexity of the environment: a user in the field might be distracted from her task by external conditions,
such as noise, or weather changes

The tablet PC provides technical and ergonomic features which are suitable for the Annotator and Data collector
roles. It supports a digital camera and enables wireless communication. Besides it is portable and its size is
anologue to an A4 paper notebook, which suits annotation needs. The real estate of the screen allows
comfortable visualization of preview and captured images, as well as thumbnail view of collected data. Thus the
device was chosen for the Mobile Collector application.

In designing the information architecture, we attempted to suit the specific issues of context of use, thus
accommodating role-specific functionalities and device-specific features. In this sense the information
architecture must suggest an easy access to the information that is most relevant, hiding the functionalities that
are not role-specific in order to hide complexity and avoid cognitive overload. In our prototype three different
layers of navigation were realized (Figure 2):
Field trip structure (top left): For simplicity, the structure of a field trip has only two different levels - several topics, with each of them containing several tasks. The structure of the field trip is always shown completely, so the learners get a holistic overview.

Concepts (down left): The concepts are provided by the author (teacher). Clicking on a concept shows all photos that are related to that particular concept.

Modes of employment (top bar):
- Search case base: This mode can be used for reading the topics and tasks that have been determined by the teacher and to look at photo collections that are already available. In order to have more place for displaying text and photos, the photo collection frame is not visible in this mode.
- Contact expert: If questions arise that cannot be solved in the field this should help in establishing a contact with an expert (e.g. through telephone or videoconference)
- Document case: Here the photo collection frame is visible, thus the findings in the field can be documented.

Figure 2: Capturing a photo

To capture a photo (Figure 2) the learner uses the video preview on the right side. After pressing the Capture button the taken photo appears under the button. If the learner is satisfied with it, she can save it into her proper collection. In a collection each photo is shown as a thumbnail image to enable easy navigation and searching.

The learner can annotate a photo (Figure 3) after clicking on its thumbnail in the collection. Then the photo is shown in the normal size, together with all its details (topic, task, collection, title). The learner can assign the name and the related concepts (keywords) to the photo, record audio annotation, or delete the photo. Because of the difficulties with text input while on the move, the user can assign the concepts by simply checking them in a predefined list. The other pupils can view the photo together with its attributes and assigned concepts, as well as to listen to the audio annotation. The teacher can reuse the photo and integrate it into a course.
Evaluation

We have tested Mobile Collector twice, always with 6 girls in the age between 10 and 14, who worked with the hardware and software for two hours. For this purpose a scenario for describing and identifying different kinds of conifers has been employed. As hardware we used a tablet PC (Figure 4) with a web camera and a microphone connected for collecting data. The gathered data could then be displayed also on a notebook and on a PDA. These three devices were connected via a wireless network, with the notebook taking the role of the server.
We assumed that the girls were not very familiar with the hardware (e.g. the handwriting recognition) and, of course, they were not familiar with the software. Therefore we planned the evaluation procedure in two steps. First they tested the hardware and software indoors to become familiar with the hardware and to learn how Mobile Collector works. To do so the following tasks were to be fulfilled:

1. Take pictures of each other and annotate them with audio and with concepts
2. View the pictures taken by the others
   a. by browsing the collections
   b. by browsing the concepts and watching the assigned photos

In the second step one group of three girls goes outdoors to collect data, the others can follow the progress by using the Mobile Viewer interface on a notebook or by using the PDA Interface on a PDA. These two interfaces have been developed just for viewing the collected data and related metadata.

All the girls were very interested in using the hardware and software. But there were differences concerning some features of Mobile Collector:
- Taking photos: The girls found taking and storing pictures very easy.
- Handwriting recognition: All students liked this feature of the tablet PC, but the software was mostly not able to recognize their handwriting. In fact Mobile Collector can be used without the need to type or write anything – the photo name is generated automatically (reflecting the date and time when the photo was taken), but can be overwritten on demand.
- Audio annotation: The girls found the process of making audio annotations very easy, but some of them did not want to do it as they did not like hearing their own voice.

In general, this experiment has shown that Mobile Collector is a tool that can be easily understood and used after a short introduction of about 30 minutes. That makes it a suitable tool for school pupils and this is the main result of our evaluation. On the other hand, we have also noticed things that have to be improved. A standard introduction course for Mobile Collector should be created. This will make the students familiar with all features of the application, it will require activity, and it should be fun. One possibility is to have the students making pictures of their peers and annotate them. Thus it is suitable to start with simple tasks in the classroom and then to continue with technically simple scenarios, i.e. indoors, with only one group of students, with good Internet connection and just few items of equipment. Possible examples include a visit of a university science lab (where only a few students are allowed to come) or in an artist’s studio (where the number of students is restricted as well). As always in education the motivation is crucial and a nice end product can be a good satisfaction for the participants. We would like to emphasize the importance of appropriate hardware that can provide good visibility even in bright sunlight.

Conclusion

Mobile technologies have a potential to enhance the current educational opportunities and virtual field trips can be considered as an example. In the RAFT project we have developed prototypes to collect and annotate data on remotely accessible field trips. They open a new paradigm of learning as they enable the embedding of constructivist learning processes in real-world contexts. This new approach is the main focus of research and development in the RAFT project.

The RAFT research deals with the investigation of the roles pupils should perform on field trips – both in the field and in the school. For these roles we currently develop a special set of tools (based on the Flash technology) that should enable pupils to perform their tasks, to collaborate and communicate with their peers. One of the primary objectives is to generate as much metadata as possible automatically, based on the current context and generated by sensors (additionally to the time parameter also other suitable attributes, e.g. GPS coordinates, temperature, etc). This will enable more precise retrieval of the data when learning objects are elaborated by students and teachers.

Acknowledgement

Remote Accessible Field Trips (RAFT) is an EU funded project in the IST programme #IST-2001-34273.
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An environment for studying collaborative learning activities

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Abstract  
Studies of collaborative learning activities often involve analyses of dialogue and interaction as well as analyses of tasks and actors’ roles through ethnographic and other field experiments. Adequate analysis tools can facilitate these studies. In this paper, we discuss key requirements of interaction and collaboration analysis tools. We indicate how these requirements lead to the design of new analysis environments. These environments support annotation and analysis of various kinds of collected data in order to study collaborative learning activities. An important characteristic of these tools is their support for a structure of annotations of various levels of abstraction, through which an activity can be interpreted and presented. This can serve as a tool for reflection and interpretation as well as for facilitation of research in collaborative learning.

Keywords  
Collaborative problem solving, analysis of collaboration, ethnographic studies

Introduction  
Collaborative learning is considered an active process that may lead to deep understanding from the students, to development of skills of critical thinking, to communication, coordination and conscious knowledge construction mechanisms (Dillenbourg, 1999). Analysis of a collaborative learning activity is important for understanding this complex process and improving the effectiveness of collaborative learning approaches. Collaboration analysis can also be used as a reflection-support mechanism for the actors involved.

Tools to support interaction and collaboration analysis have been used in the field of learning technology design and human-computer interaction (Dix et al., 1998). In the educational field, analysis of collaboration and interaction between the actors (students, tutors etc.), the artefacts and the environment is a process that can support understanding of learning, evaluate the educational result and support design of effective technology. A number of tools and methodologies have been proposed, like those related to the Cool Modes environment (Gassner et al., 2003), and the combination of qualitative evaluation and social network analysis (Martinez et al., 2003), while a useful contribution to the field is made by Martinez, Fuente and Dimitriadis (1993) who proposed an abstract representation of collaborative action.

In this paper, we focus on tools for analysis of synchronous collaborative learning activities that are independent of a specific task and collaboration support environment.
Tools to support analysis

Recent theoretical advances in Computer Supported Collaborative Learning (Koschmann et al., 2002; Wasson et al., 2003) and the requirements that emerge from the filed, (like analysis of interaction in the class, in working groups, analysis of chat and forums and so on), lead to the conclusion that effective analysis-support tools should be independent of the methodology used; they should, accommodate and integrate multiple data formats and, be easy to use by typical education researchers and analysts; they should, be inter-operable with statistical analysis and other typical data processing tools as well. They should also produce results in various formats and be flexible in supporting multiple views over the data, as these data can become the main repository of information for educational research which may be reviewed under different research perspectives. The design of tools that meet such requirements is the focus of the research reported here. These tools support methodologies for design and evaluation of interactive learning systems (e.g. Tselios et al., 2003; Avouris et al., 2003).

In the following, we describe the functionality of a new environment for the analysis of group learning that integrates multiple sources of behavioural data produced by multiple logging and monitoring devices. This environment is made of two distinct components.

The first one, the Activity Analysis (AA), handles history logfiles of activity and textual communication. Through this Activity analysis tool, the researcher can playback the activity off-line and annotate the produced diagrammatic solution. This environment produces quantitative measures of collaborative activity and permits visualization of actors and their roles off-line. There are similarities of the AA tool with the structural analysis components described in Gassner et al. (2003). AA has been associated originally to the collaborative modelling environment ModellingSpace (Avouris et al., 2003) and later to the collaborative flowcharting environment Synergo (http://www.ee.upatras.gr/hci/synergo). Both these environments support direct communication and problem solving activity of a group of distant students, manipulating a shared diagrammatic representation.

![Diagram](http://example.com/diagram.png)

**Figure 1.** Overview of the analysis environment

The second one, called Collaboration Analysis Tool (ColAT) is a tool, independent of a specific collaboration support environment, to analyse multimedia data, collected during collaborative activities and review the activity
by annotating the observed behaviour and building interpretative joint goal structures. This belongs to the
general class of qualitative analysis tools, with special emphasis on analysis of collaborative learning activities.

The focus of the reported research has been put on study of scenarios of synchronous computer-supported
collaborative learning, in which the actors are spatially dislocated, a factor which imposes additional complexity
in the analysis task. In the following section, the main features of these analysis environments are described,
followed by a discussion on the implications of this research for the field of technology-enhanced learning
research and the perspectives of this research effort.

Method and tools of analysis

Overview

In Figure 1, an overview of the described analysis environment is outlined. In a typical synchronous
collaborative learning situation, two or more actors, supported by networked equipment, collaborate at a distance
by communicating directly and by acting in a shared activity board. A graphic or diagrammatic representation of
a solution to a given problem may appear in this shared board. This activity is typically monitored through
automatic logging of the main events and recording the activity of the actors in the shared activity board and of
the dialogue events if they are in text form. Logging of events may also be done by observers, like “at 14:30
person X call viewed an animation created by person Y”. In addition, the dialogue can be captured through video
and audio recording if videoconferencing technology has been implemented, while additional information of the
activity and the context within which this has taken place, may be captured in various forms (still images, textual
observations, video and audio recordings etc.).

This setting may result in a large amount of data in various forms. In the following, tools for analysis of data
collected in such collaborative situation and interpretation of the collaborative learning activity are described.
The analysis framework involves two distinct phases and associated tools.

Activity Analysis

During the first phase of this analysis process, the Activity Analysis tool is used for visualization and processing
mainly of the history logfiles, produced during collaborative learning activities. These logfiles contain
time-stamped events, which concern actions and exchanged text messages of partners engaged in the activity, in
sequential order. These events have this typical structure:

<time-stamp>, <actor>, <event-type>, <attributes>, <comments>

The logfile events are produced by exchanged control and textual dialogue messages and need to adhere to a
defined XML syntax. These events can be viewed, commended and annotated by the tools discussed here. The
activity can be reproduced using the Playback Tool that reconstructs the group problem-solving activity on the
students’ workstations desktop step by step, through a single view. Annotation of the events is done, according
to specific analysis models that permit building of an abstract view of the activity.

OCAF: An example of an annotation scheme

An example of an annotation model that can be used by Synergo is the Object-oriented Collaboration Analysis
Framework (OCAF) (Avouris et al., 2003), which is particularly suitable for analysis of collaborative problem-
solving activity. The activity playback and solution annotation tool is shown in Figure Figure 2. The result of
this phase is an annotated history of the problem-solving activity and of the produced diagrammatic solution. In
the example ofin Figure Figure 2 one can see the graphic representation of this history and annotation of the
solution in the shared activity board. In a separate window, the history of textual dialogue events is presented.
Each item of the diagrammatic solution of a problem (a concept map representing a web service in this case) is
associated to the sequence of events that lead to its existence. So the sequence (I),(C),(M),(R) (Figure 2)
represents the following events: (I)nteration of this object by actor A, (C)ontestation of this insertion by Actor B,
(M)odification of the object by Actor A and (R)ejection of the modification of Actor B. This view of the activity
depicts the intensity of collaboration in relation to specific parts of the diagram and identifies the collaboration
patterns of the activity.
AA support for automatic annotation of collaborative learning activity

Generation of the annotated view by interpreting one by one the history logfile events is a tedious process; the AA environment facilitates this process, by allowing association of the events, automatically generated by the collaboration support software, to classes of annotations. So for instance, all the events of type "Modification of concept text" in a concept-mapping tool are associated to the "Modification" annotation of the OCAF scheme.

Not all events however can be automatically annotated in this way. For instance, textual dialogue messages need to be interpreted by the analyst and, after establishing their meaning and intention of the interlocutor, they need to be annotated accordingly. So for instance, a suggestion of a student on modification of part of the solution can be done either through verbal interaction or through direct manipulation of the objects concerned in the shared activity board. OCAF proposes a uniform scheme for annotation and interpretation of action and dialogue events. The new annotated logfile can be inserted in the CoLAT environment, used subsequently in the second phase of analysis, is discussed in the next section.

Figure 2. A jointly built model, annotated according to the OCAF scheme.

Figure 3. Charts of evolution of collaborative activity. (a) insert and delete activity, (b) chat messages, (c) mixed view, (d) collaboration factor

Statistics of collaboration, the collaboration factor

Additional views can be generated, that represent the collaborative process. These are statistics of collaboration activity per time slot of activity. Another view relates to the graph of evolution of the Collaboration Factor (CF). This is an index, which is calculated from the patterns of collaboration that generated the solution. CF takes higher values if most components have been built with contribution of all partners, while it is low if there is no joint contribution of the partners in construction of parts of the solution.
In figure 3 some typical views are shown, which depict the evolution of various types of events during the activity. So in chart (a) of Figure 3 one can see the evolution of the Insert (red) and Delete (blue) events in the shared activity board, while in chart (b) of the same figure the textual messages exchanged in the same study. Through these views, one may observe the level of activity during various phases of problem solving. In our example, is shown that during the fifth time period, the partners involved were more engaged in verbal interaction than acting in the shared activity board.

Collaboration Analysis

In the second phase, the Collaboration Analysis Tool (ColAT) is used for building an interpretative model of the joint activity in the form of a joint plan or sequence of pursued goals, as they may be produced by the observed behaviour. ColAT permits fusion of multiple data by interrelating them through the concept of universal activity time. The analysis process during this phase, involves interpretation and annotation of the collected data, which takes the form of a multilevel description of the collaborative activity.

The ColAT tool, discussed in more detail in (Avouris et al., 2003c), uses a theatre scene as an organizing metaphor and framework. According to this, one can observe the action by following the plot from various standpoints. The event-view permits study of the details of action and interaction, the task-view permits study of purposeful chunks of action, while the goal-view studies the activity at the strategic level, where most probably cognitive processes of the actors and the decisions on collaboration are more clearly depicted.

This three-level model is built gradually: the first level, the events level, is directly associated to log files of the main events and is related through the time-stamps to the stream media like video. The second level describes tasks at the actor or group level, while the third level is concerned with goals of either individual actors or the group. In Figure 3 the typical environment of the ColAT tool for creation and navigation of a multi-level annotation and the associated stream media is shown. The three-level model is shown on the right, while the video/audio window is shown on the left.

The original sequence of events contained in the log file is shown as level 1 (events level) of this multilevel model. The format of events of this level in XML, is that produced by the AA environment. Thus the output of the first phase can feed into ColAT, as first level structure. A number of such events can be associated to an entry at the task level 2. Such an entry can have the following structure: 

```
<ID, time-span, entry_type, actor(s), comment >,
```

where ID is a unique identity of the entry, time-span is the period of time during which the task took place, type is a classification of the entry according to a typology, defined by the researcher, followed by the actor or actors that participated in the task execution, a textual comment or attributes that are relevant to this type of task entry. Examples of entries of this level are: "Student X inserts a link ", or "student Y contests the statement of Z".

In a similar manner, the entries of the third level (Goal level) are also created. These are associated to entries of the previous Task level. The entries of this level describe the activity at the strategy level as a sequence of interrelated goals of the actors involved or jointly decided. This is an appropriate level for description of plans, from which coordinated and collaborative activity patterns may emerge. In each of these three levels, a different typology for annotation of the entries may be defined. This may relate to the domain of observed activity or the analysis framework used. For entries of level 1 the OCAF framework may be used, while for the task and goals level different annotations have been proposed.

Multimedia in ColAT

Various streaming media, such as digital video or audio files can be viewed using the ColAT tool from any level of its multi-level model of the activity. As a result, the analyst can decide to view the activity from any level of abstraction he/she wishes, i.e. to play back the activity by driving a video stream from the task or the goal level. This way the developed model of the activity is directly related to the recorded field events.

Other media, like still images of the activity or of a solution built, may also be associated to this multilevel model. Any such snapshot may be associated through a timestamp to a point in time, or a time slot, for which this image is valid. Any time the analyst requests playback of relevant sequence of events, the still images appear in the relative window. This facility may be used to show the environments of various distributed users during collaboration, to illustrate the use of tools and other artefacts, and so on.
The possibility of viewing a process using various media (video, audio, text, logfiles, still images), from various levels of abstraction (event, task, goal level), is an innovative approach. It combines in a single environment the hierarchical analysis of a collaborative activity, which has already been proposed and used by many frameworks of analysis, like Activity Theory (Nardi 1996), Goals, Operators, Methods and Selection (GOMS, John, and Kieras, 1996), Hierarchical Task Analysis, (Hollnagen, 2003) to the sequential character of observational data.

Experimental studies

A number of experimental studies have been recently performed using these tools. These relate to various aspects of collaborative learning and problem solving. In Fidas, Komis, Tzanavaris, Avouris (in press) the effect of heterogeneity of the available resources has been studied for various collaborative-learning experiments. In Avouris and colleagues (2003d) the effect of the floor control mechanism is studied, while in Komis, Avouris and Fidas (2002) evaluation of the effectiveness of the environment in the educational process is discussed along various dimensions, like group synthesis, task control, content of communication, roles of the students and the effect of the tools used. In these studies, various versions of the presented tools have been used. First the Activity Analysis (AA) tool has been used for playback and annotation of the activity, while statistics and estimation of the collaboration factor have been produced. Subsequently the produced video and sequences of still images, along with the History logfiles of the studies were fed in the Collaboration Analysis (ColAT) environment through which the goal structures of the activities were constructed.

These studies demonstrated that there are many issues, relating to collaborative learning, that necessitate further research. So, experimental tools are needed to support and facilitate such studies. For this reason analysis tools, like the ones presented here, can be useful means towards a better understanding of the issues, related with collaborative learning.

Conclusions

In this paper, we outlined the main features of two new tools that facilitate analysis of complex field data of collaborative problem solving activities, the Activity Analysis (AA) and the Collaboration Analysis Tool (ColAT).
The first one, a playback and solution annotation tool permits re-construction of the problem solution and visualisation of the partners’ contribution in the activity space. AA is a tool that automates processing of history logfiles and puts emphasis on quantitative analysis.

The second tool supports building a multilevel interpretation of the solution, from the observable events level to the cognitive level in combination with multimedia view of the activity. Through this, a more abstract description of the activity can be produced and analysed at the individual as well as the group level. This tool combines multiple points of view and follows the qualitative analysis tradition.

It should be observed that the two presented tools are complementary in nature, the first one, used for building annotation of the problem solving at the event level, while the second one leading to more interpretative structures. The result of the first phase can feed the second phase, in which case the first level of the multilevel structure is already filled. The higher levels are in this case built, using ColAT. However the two tools are quite independent since their use depends on the available data and methodological framework of analysis. The first one has been so far tightly linked to the specific synchronous problem-solving environments, while the ColAT is more generic and can be used for studying any kind of collaborative activity, which has been recorded in multiple media.

Acknowledgement

The development of the tools described in this paper has been partly funded by the European Commission IST “School of Tomorrow” program, through the research project “ModellingSpace” IST-2000-25385. Special thanks are also due to the reviewers of this paper for valuable comments on earlier draft of the manuscript.

References


Analyzing Problem's Difficulty based on Neural Networks and Knowledge Map

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Abstract
This paper proposes a methodology to calculate both the difficulty of the basic problems and the difficulty of solving a problem. The method to calculate the difficulty of problem is according to the process of constructing a problem, including Concept Selection, Unknown Designation, and Proposition Construction. Some necessary measures observed in the problem construction process are also defined in this paper in order to formulate and calculate the difficulties. Beside the difficulty of the basic problem, four difficulty dimensions for problem solvers to realize what kinds of abilities they are lack of to deal with the problem, including Identification, Elaboration, Planning, and Execution, corresponding to the each step of problem solving process are also analyzed and designed by the artificial neural networks in this paper. By these difficulty measures learners can understand what kind of problems they meet and what sort of problem solving strategies they use in solving the problem. To verify our goals, an Item Generating System is constructed for demonstrating and supporting the difficulty calculation in the end of this paper.

Keywords
Difficulty of problems, Knowledge map, Neural networks, Problem solving process, Least-mean square

Introduction
Knowledge Storage is an important issue in CAI. When suitable knowledge structure is designed, the CAI system can be used to proceed with tutoring, solving problems, or misconception diagnosing. The knowledge structure, which used here, is Knowledge Map. Knowledge Map consists of two major parts, Concept Hierarchy and Concept Schema (Kuo et al., 2002). Concept Hierarchy presents the hierarchical relationship among concepts. Concept Schema stores the remaining information, which integrates the definition, example, and other relations with associated concepts. In Figure 1, the Concept Hierarchy is demonstrated in gray block with link among concepts and the Concept Schema of each concept is demonstrated in the white block.

The Knowledge Object is able to use for representing knowledge (Tung, 2002). For example, Physics has four Knowledge Objects as shown in Figure 2: Object, Physics Phenomenon, Physics Law, and Physics Quantity. Each Knowledge Object has some relationships to its related Knowledge Object. For example, a Physics Phenomenon changes according to some Physics Laws and may influence some values of Physics Quantity. The Core Knowledge Object, which expressing main idea of the knowledge, is the Physics Phenomenon in this example.

This research uses previous the Knowledge Object to formulate the difficulty of a problem. The similar study in problem difficulty determination is computerized adaptive testing (CAT). CAT selects items from item bank,
and the difficulty setting in each item which needs to be adjusted according to item response theory. The difficulty-setting strategy proposed in this paper use knowledge analysis based on Knowledge Map and increase difficulty reliability by neural network training.

Section 2 describes two metaphors for problem solving and the four-step problem solving process. The problem model and its construction process are analyzed in Section 3. Section 4 discusses the calculation of difficulty features and difficulty dimensions. An Item Generating System (IGS) which is given as an example for showing the difficulties calculations is built in Section 5. Section 6 gives a brief conclusion and some possible future studies.

Metaphors for Problem Solving

It is a problem when someone has a goal but the goal is blocked for lack of information resources (Kahney, 1993). Two metaphors, Problem Graph and Problem Matrix can be represented for solving a problem (Kuo et al., 2003). Figure 3 gives an example of Problem Graph, which use graph structure to illustrate a problem. There are six concepts ("Object", "Free Fall", "Displacement", "Time", "19.6", "unknown") and five links (one "Proceed", two "Has", and two "Is") compose a problem graph. These concepts and links make up five propositions and these propositions can be transformed to the related proposition matrix as shown in the bottom of Figure 3.

Another metaphor, Problem Matrix, focuses on the manipulation of concepts and relations which can be used for solving the problem. Figure 4 shows a Problem Matrix example for the Free Fall problem in Physics. Two Physics laws ("Displacement = 0.5 * Acceleration * Time ^ 2" and “Velocity = Acceleration * Time”) present the relationships among four major concepts of Physics Quantity ("Displacement", “Time”, “Velocity” and “Acceleration”). The Problem Matrix for such kinds of problems can be written as Figure 4 shown below.
Object Free Fall Displacement 19.6 Time Unknown
Proceed Has Is Is Is
1 1 0 0 0 0
1 0 1 0 0 0
1 0 0 1 0 0
0 0 1 0 1 0
0 0 0 1 0 1

Figure 3. Example of the Problem Graph and related proposition matrix

<table>
<thead>
<tr>
<th></th>
<th>Displacement</th>
<th>Time</th>
<th>Velocity</th>
<th>Acceleration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proceed</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Has</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Has</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Is</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Is</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>

Figure 4. Example of Problem Matrix

With these two problem metaphors described above, a four-steps problem solving strategy proposed in previous study (Hsu et al., 2002). Since problem solving has already been discussed for a long while from 1910 (Dewey, 1910; Polya, 1965; Deek et al., 1999), those steps took in this paper will follow the four types of schema in problem solving proposed by Marshall in 1995 (Marshall, 1995). By using these schemas, a problem solving system was constructed in our previous works and its system architecture in Figure 5 (Cheng et al., 2001; Tung, 2002; Kuo et al., 2002). A Problem Solving System loads a problem, which will be processed through four steps: problem identification, problem elaboration, problem planning, and problem execution. All these steps get knowledge from the Knowledge Base which stores in the long-term memory and produces different metaphors, Problem Graph and Problem Matrix store in short-term memory.

Figure 5. Four-steps of Problem Solving

With the problem metaphors and the problem solving strategies, this study proposes a difficulty definition corresponding to each stage in the process of problem solving. Since the difficulty of problems depends on what kind of problems the students dealing with, therefore, before we talking about what is difficulty and how to calculate the difficulty of problems, the problem model and the process of constructing a problem should be designed and analyzed first.

**Problem Model and Difficulty Analysis**

**Problem Model Design**

Most of the problems can be separated into several sub-problems. A problem which can be separated is called complex problem. On the contrary, a problem can not be separated is called simple problem (or basic problem). The basic problem in this paper is defined as there is only one Core Knowledge Object existed in the problem. Furthermore, a problem also has some unknown attributes (the goal of the problem) and given attributes (the resource for reaching the goal).
To sum up the description above, basic problem model has three major parts: Sub-Problem Flag Attribute, Given Attributes and Unknown Attributes, which Sub-Problem Flag Attribute presents the Core Knowledge Object. Figure 6 is an example of Free Falling problem with given attributes (distance and velocity) and the unknown attribute (time).

A complex problem is composed by several basic problems. The relations among basic problems are defined as Sub-Problem Connection. The Sub-Problem Connection contains three parts: two related attributes for the different basic problems and the relation type between these two basic problems. Figure 7 illustrates a complex problem model with two sub-problems, which has one Sub-Problems Connection for linking both of sub-problems.

<table>
<thead>
<tr>
<th>Basic Model</th>
<th>Problem</th>
<th>Corresponding Concepts</th>
<th>Example of Physics Problem</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sub-Problem Flag Attribute</td>
<td>Free Fall Phenomena</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Given Attributes</td>
<td>Value of Distance</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unknown Attributes</td>
<td>Value of Velocity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unknown Attributes</td>
<td>Ask for Value of Time</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 6. Basic problem model for the Free Falling problem in Physics

<table>
<thead>
<tr>
<th>Basic Problem 1 Model</th>
<th>Sub-Problem Flag Attribute</th>
</tr>
</thead>
<tbody>
<tr>
<td>Given Attributes</td>
<td></td>
</tr>
<tr>
<td>Unknown Attributes</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Sub-Problems Connection</th>
<th>Related Basic Problem 1 Attribute</th>
</tr>
</thead>
<tbody>
<tr>
<td>Related Basic Problem 2 Attribute</td>
<td></td>
</tr>
<tr>
<td>Relation between two Attributes</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Basic Problem 2 Model</th>
<th>Sub-Problem Flag Attribute</th>
</tr>
</thead>
<tbody>
<tr>
<td>Given Attributes</td>
<td></td>
</tr>
<tr>
<td>Unknown Attributes</td>
<td></td>
</tr>
</tbody>
</table>

Figure 7. Problem model of two sub-problems (Complex Problem Model)

Using the problem model designed above to construct a problem we need three major steps, they are Concept Selection, Unknown Setting, and Proposition Construction as Figure 8 shown below. Concept Selection sets the Sub-Problem Flag Attribute of the basic problem. This action decides the main concept of the problem. The second step, Unknown Setting, determines the Given Attributes and the Unknown Attributes in the problem. The way to find the given and unknown attributes depends on the problem metaphor – Problem Matrix.

Problem Matrix defines the possible manipulation way of the relations and concepts of the problem. Some concepts can be set as the Unknown Attributes and some can be set as the Given Attributes. This setting will be judged if it is solvable or unsolvable by using the Problem Matrix. The last step is Proposition Construction. Using the setting of attributes in the Problem Matrix, the Proposition Construction step could be able to build question sentences in natural language. All these three steps need the Knowledge Map introduced in Section 1.

Figure 8. Process of constructing a problem (Problem Construction Process)

Difficulty Analysis

Each step of constructing a problem makes the difficulty of the problem changes. Ignoring the reading ability of learners, this paper only focuses on the first two steps of problem construction process. In Concept Selection,
obviously, the number of sub-problems will influence the difficulty of the problem. Number of Needed Attributes indicates how many concepts are needed to learn before students can solve such kinds of problem, and it also influences the next two features, Learning Sequence and Concept Depth. The Learning Sequence is a difficulty feature that indicates the learning order for learners and the Concept Depth shows the specialization degree of the core concept of the problem.

The second step, Unknown Setting, affects all attributes in the problem. Number of Unknown is one difficulty feature which is usually used in measuring problem. Number of Given Attribute indicates the information that this problem supports. Number of Elaborating Attributes shows the hidden information cover up in the problem. Attributes setting also influence Mathematical Complexity, which can be another difficulty feature of the problem. All difficulty features are arranged in Table 1. Disregarding the mathematical complexity this paper focuses on the basic problem model, it means the Number of Sub-Problem and Mathematical Complexity will be omitted in the following Section.

<table>
<thead>
<tr>
<th>Element</th>
<th>Difficulty Feature</th>
<th>Denotation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Selected Concepts</td>
<td>Number of Sub-Problems</td>
<td>$\gamma_{sub\ prob}$</td>
</tr>
<tr>
<td></td>
<td>Number of Needed Attributes</td>
<td>$\gamma_{need\ attr}$</td>
</tr>
<tr>
<td></td>
<td>Learning Sequence</td>
<td>$\gamma_{learn\ seq}$</td>
</tr>
<tr>
<td></td>
<td>Concept Depth</td>
<td>$\gamma_{cpt\ depth}$</td>
</tr>
<tr>
<td>Attributes Setting</td>
<td>Number of Unknown</td>
<td>$\gamma_{unknown}$</td>
</tr>
<tr>
<td></td>
<td>Number of Given Attributes</td>
<td>$\gamma_{given\ attr}$</td>
</tr>
<tr>
<td></td>
<td>Number of Elaborating Attributes</td>
<td>$\gamma_{elb\ attr}$</td>
</tr>
<tr>
<td></td>
<td>Mathematical Complexity</td>
<td>$\gamma_{math\ cpx}$</td>
</tr>
</tbody>
</table>

**Difficulty Calculation**

**Difficulty of the Basic Problems**

The eight difficulty features discussed in the previous section compose the problem difficulty. This section concentrates on the calculation of each difficulty feature for the Basic Problems, hence, the Number of Sub-Problems and Mathematical Complexity are ignoring. Some definitions of prior measures are required for difficulty calculation and listed below. Most of them are related to the Knowledge Map.

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Definition</th>
</tr>
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<tbody>
<tr>
<td>$#\text{given\ attr}$</td>
<td>number of given attributes in the problem</td>
</tr>
<tr>
<td>$#\text{unknown}$</td>
<td>number of unknown attributes in the problem</td>
</tr>
<tr>
<td>root</td>
<td>the root of Knowledge Map</td>
</tr>
<tr>
<td>$\theta_i$</td>
<td>$i^{th}$ concept</td>
</tr>
<tr>
<td>$\text{CS}(\theta_i)$</td>
<td>Concept Schema of $i^{th}$ concept</td>
</tr>
<tr>
<td>size($\text{CS}(\theta_i)$)</td>
<td>number of attributes in concept from full Concept Schema</td>
</tr>
<tr>
<td>height($\theta_i$)</td>
<td>the height of sub-tree from $i^{th}$ concept</td>
</tr>
<tr>
<td>attr$_{LS}(\theta_i)$</td>
<td>learning sequence attribute stored in Concept Schema</td>
</tr>
<tr>
<td>attr$_{manip\ cpx}(\theta_i)$</td>
<td>attributes extracted to manipulating concepts in Problem Matrix</td>
</tr>
<tr>
<td>size(attr$_{manip\ cpx}(\theta_i)$)</td>
<td>number of manipulating concepts in Problem Matrix</td>
</tr>
<tr>
<td>attr$_{max\ unknown}(\theta_i)$</td>
<td>maximum number of unknown in $i^{th}$ concept</td>
</tr>
</tbody>
</table>

Using the measurement listed above, each difficulty feature of problems can be formulized as below:

\[
\gamma_{need\ attr} = \text{size}(\text{CS}(\theta_i)) / \arg \max_{\theta \in \text{KM}} \text{size}(\text{CS}(\theta))
\]

\[
\gamma_{learn\ seq} = \text{attr}_{LS}(\theta_i) / \arg \max_{\theta \in \text{siblings}(\theta)} \text{attr}_{LS}(\theta)
\]

\[
\gamma_{cpt\ depth} = (\text{height}(\text{root}) - \text{height}(\theta_i)) / \text{height}(\text{root})
\]

\[
\gamma_{given\ attr} = (\text{size}(\text{attr}_{manip\ cpx}(\theta_i))) - \#\text{given\ attr} + 1) / \text{size}(\text{attr}_{manip\ cpx}(\theta_i))
\]

\[
\gamma_{unknown} = \#\text{unknown} / \text{attr}_{max\ unknown}(\theta_i)
\]

\[
\gamma_{elb\ attr} = (\text{size}(\text{attr}_{manip\ cpx}(\theta_i))) - \#\text{given\ attr} - \#\text{unknown} + 1) / \text{size}(\text{attr}_{manip\ cpx}(\theta_i))
\]
Later part of the paper will give a simple example for calculating each difficulty features.

**Difficulty Dimensions for Problem Solvers**

Although the difficulty features corresponding to the problem metaphors and the problem construction process is analyzed and designed in this paper, learners still cannot use them easily to figure out what is going wrong while they are solving problem. Therefore, the previous discussed problem solving steps are taken for this paper to design four difficulty dimensions for problem solvers to realize what kinds of abilities they are lack of to deal with the problem, including Identification Difficulty ($\gamma_{idf}$), Elaboration Difficulty ($\gamma_{elb}$), Planning Difficulty ($\gamma_{pln}$), and Execution Difficulty ($\gamma_{exc}$). All the values of these four difficulty dimensions come from the setting of difficulty features.

Because the Identification Difficulty focuses on the concept discussed in the problem, there are two difficulty features related to this dimension – Learning Sequence and Concept Depth. The Elaboration Difficulty dimension emphasizes the attributes, Number of Needed Attributes, Number of Given Attributes, and Number of Elaborating Attributes, which are needed to solve the problem. Number of Unknown and Number of Elaborating Attributes impact the Planning Difficulty dimension; therefore the planning difficulty dimension needs students to know the relation of unknown attributes in the problem. Number of Unknown also decides the difficulty dimension of Execution Difficulty. To transform difficulty features to difficulty dimensions, the transform formulae are listed below: ($\omega_i$ indicates the customized weight)

$$\gamma_{idf} = \omega_{21} \times \gamma_{learn_seq} + \omega_{31} \times \gamma_{cpt_depth}$$
$$\gamma_{elb} = \omega_{12} \times \gamma_{need_attr} + \omega_{42} \times \gamma_{given_attr} + \omega_{62} \times \gamma_{elb_attr}$$
$$\gamma_{pln} = \omega_{33} \times \gamma_{unknown} + \omega_{33} \times \gamma_{elb_attr}$$
$$\gamma_{exc} = \omega_{44} \times \gamma_{unknown}$$

All these weights can be set and adjusted by training the neural networks. A neural network is defined as a machine which modeling a particular task of function (Haykin, 1999). This research applies least-mean square algorithm for training customized weights which transforming difficulty features to difficulty dimensions. There are four linear filters of neuron model in the network as shown in Figure 9. In the previous definition Identification Difficulty have two influence features, Learning Sequence and Concept Depth. This idea is constructed in the first neuron model ($N_1$), which has one output ($\gamma_{idf}$), two inputs ($\gamma_{learn_seq}$, $\gamma_{cpt_depth}$), and two synaptic weights ($\omega_{21}$, $\omega_{31}$). Other three neuron models also have similar construction. With supervised by teachers, the weights among neurons could be changed possibly. Because of the teacher may find out the difficulty dimension faced by the students (problem solvers) are different to the output of neural networks as Figure 9 shown below.

Although using neural network can find objective difficulty features, those values can not be adjusted according to different capability learners. Two possible solutions can deal with this problem. One of them is problem-process record, which registers each problem solving steps from learners including previous solving problem. The other one is item response theory which mentioned in the beginning of this paper. The critical point of integrating IRT into difficulty setting is the limitation of unidimensionality in IRT.

**Item Generating System**

In previous research, the Item Generating System needs Problem Matrix to construct a problem (Kuo et al., 2003). To integrate with the difficulty calculation the system needs another data structure, Difficulty Table, for estimating problem difficulty as shown in Figure 10.
Figure 11 shows a snapshot of the generated problem: "In sky, raindrop exceeds the motion of constant acceleration. The initial velocity is 0 m/s. Acceleration is 5 m/s². The final time is 5 s. Ask for the final value of velocity." The Knowledge Map in the example is the sub-tree of Kinematics in Figure 1. This problem has one unknown and three given attributes. In the Knowledge Map, there are eleven attributes in Concept Schema of the "Motion of Constant Acceleration"; seven of them are manipulating concepts and three of them are manipulating relations. Those manipulating attributes construct the Problem Matrix as Figure 12. According to these settings, six difficulty features are listed below in Table 2.

Figure 9. Training Weights of Neural Network

Figure 10. Problem Generating System with difficulty calculation

Figure 11. Difficulties of problem solving steps calculated by the Item Generating System
After getting those difficulty features, four difficulty dimensions could be transformed into difficulty dimensions. The weights are trained by neural networks which as shown in Figure 9, and the weight values among neurons are:

\[
\begin{align*}
\omega_{21} &= 0.7122 \\
\omega_{31} &= 1.6557 \\
\omega_{12} &= 0.9500 \\
\omega_{42} &= -0.0676 \\
\omega_{62} &= 0.3815 \\
\omega_{53} &= -0.8568 \\
\omega_{63} &= 0.5786 \\
\omega_{54} &= -0.9987
\end{align*}
\]

And the values of difficulty dimensions can be calculated as follow:

\[
\begin{align*}
\gamma_{idf} &= 0.7122 \times 1 + 1.6557 \times 0.5 = 0.66 \\
\gamma_{elb} &= 0.9500 \times 0.8 - 0.0676 \times 0.7 + 0.3815 \times 0.4 = 0.68 \\
\gamma_{pln} &= -0.8568 \times 0.5 + 0.5786 \times 0.4 = 0.7 \\
\gamma_{exc} &= -0.9987 \times 0.5 = 0.7
\end{align*}
\]

These four difficulty dimensions can help learners to understand the emphatic problem solving techniques they need to have when solving the problem.

**Conclusions**

This study proposes a methodology for calculating the problem difficulty based on the four-step problem solving strategy. This difficulty helps learners realize the emphasized problem solving strategy in the basic problem. To calculate the difficulty of the problem, this paper first analyzes the problem construction process of basic problems that is Concept Selection, Unknown Setting, and Proposition Construction. Ignoring the last step, some difficulty features can be observed during the problem is constructed. Six of them can be translated to four difficulty dimensions, according to the problem solving strategies – Identification, Elaboration, Planning, and Execution. The simplest neural network and its weights among neurons are applying to the transformation process which transforms the difficulty dimensions from the difficulty features.

An example system, Item Generating System, is used to generate item for learners to practice dynamically. The system is also constructed to demonstrate the difficulty calculation. Learners can observe the lack of abilities in solving problems from the system when they get wrong during the solving process. The possible future works include how to calculate the difficulty for the complex problems and how to measure the Mathematical Complexity which is also a big issue to affect the difficulty calculation for problems. Another research subject is the way to diagnose learners’ problem-solving abilities which is the application of using difficulty features. How to integrate IRT into this difficulty setting method also becomes an interesting issue in this study.
References


Integrating XQuery-enabled SCORM XML Metadata Repositories into an RDF-based E-Learning P2P Network

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Abstract
Edutella is an RDF-based E-Learning P2P network that is aimed to accommodate heterogeneous learning resource metadata repositories in a P2P manner and further facilitate the exchange of metadata between these repositories based on RDF. Whereas Edutella provides RDF metadata repositories with a quite natural integration approach, XML metadata repositories have to overcome considerable incompatibility between XML’s tree-like hierarchical data model and RDF’s binary relational data model in order to be integrated into Edutella. In this paper we investigate a generic approach for integrating XML metadata repositories into Edutella in terms of an XQuery-enabled native XML database containing SCORM XML metadata. We first propose a triple-like XML-based common data view to cross incompatibility between arbitrary XML data model and RDF data model, then discuss the wrapper program implementation for XML metadata repositories based on the wrapper-like Edutella content provider integration architecture. At last, we propose a generic approach for querying complex XML data schemas in Edutella through QBE (Query by Example), and present the design of a QBE-based SCORM query GUI that can be used to query SCORM XML metadata in Edutella in the RDF syntax.

Keywords
Resource Description Framework, Peer-to-Peer, XQuery, Sharable Content Object Reference Model, Query by Example

Introduction

The open source project Edutella is an RDF (Resource Description Framework) based E-Learning P2P (Peer-to-Peer) network that is aimed to accommodate heterogeneous learning resource metadata repositories in a P2P manner and further facilitate the exchange of metadata between these repositories based on RDF (Nejdl et al., 2002; Nejdl et al., 2003). At present Edutella is geared towards learning resource metadata repositories that are constructed based on several popular learning resource metadata sets, e.g., DCMES (Dublin Core Metadata Element Set) (DCMI, 1999), IEEE LOM (Learning Object Metadata) (IEEE LTSC, 2002), IMS learning resource metadata specification (IMS, 2001), SCORM (Sharable Content Object Reference Model) (ADL, 2003), etc., though its architecture and design do not make any assumptions about the applied metadata sets. In Edutella we make only one essential assumption that all Edutella resources can be described in RDF and further all Edutella functionalities can be mediated through RDF statements and the queries against these statements, as we believe the modular nature of RDF metadata to be especially suitable for distributed P2P settings. This essential assumption obviously leads to RDF being the most naturally applicable metadata representation in Edutella and RDF metadata repositories being the most natural form of Edutella content providers.

In spite of that, in practice we usually have to address another important type of Edutella content providers: XML (eXtensible Markup Language) metadata repositories containing XML binding metadata of aforementioned learning resource metadata sets. As a matter of fact, nowadays large amounts of learning resource metadata still exist on the Web in the format of XML. In comparison to RDF metadata repositories, at least at present XML metadata repositories still occupy a quite dominant place in E-Learning. Apart from the reason that simple XML has a flatter learning curve and a more straightforward binding strategy to popular learning resource metadata sets than RDF, another important reason is that XML has a longer history to be applied for binding E-Learning standards and specifications. Taking the IMS learning resource metadata specification as an example, it has provided the XML binding since version 1.0 released in August 1999,

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whereas its RDF binding has been introduced since version 1.2 released in June 2001. In consequence, currently most of existing educational repositories are XML-based (Duval et al., 2001; Liu et al., 2001; Qu et al., 2002). They contain a large amount of learning content to be addressed by Edutella.

Besides above reasons, the popularity of XML metadata repositories in E-Learning can also be attributed to a new type of XML back-end system: the native XML databases (Chaudhri et al., 2003). Unlike some other XML back-end systems such as RDBs (Relational Databases) and OODBs (Object-oriented Databases), in which XML metadata usually need to be pre-processed and stored in some transformed representations, e.g., decomposed relational tables in RDBs or decomposed objects in OODBs, the native XML databases provide a more straightforward way for constructing XML metadata repositories in that all XML metadata profiles can directly be stored and managed in their original hierarchical forms without the need of any pre-processing. In a native XML database, the database schema used to define how XML metadata are stored is virtually identical to the XML data schema defined by XML DTD (Document Type Definition) or XML Schema. Therefore, based on a specific XML data schema, multiple XML metadata profiles can be contained in a single collection thus be queried as a whole through using W3C XPath (Clark et al., 1999) or W3C XQuery (Boag et al., 2003). Also XML metadata profiles can easily be updated through direct manipulation on XML fragments instead of on the whole metadata profiles. In overall, all these features of native XML databases satisfactorily fit into the typical usage and management scenarios of learning resource metadata thus greatly promote the application of XML metadata repositories in E-Learning. Taking into account the current application status of XML metadata repositories, in this paper we focus on native XML metadata repositories to investigate the approach for integrating XML metadata repositories into Edutella.

Edutella Content Provider Integration Architecture

The P2P infrastructure design of Edutella is based on Sun’s open source P2P platform JXTA (Sun Microsystems Inc., 2003). In order to integrate heterogeneous content provider peers, Edutella uses a wrapper-like (Papakonstantinou et al., 1995) content provider integration architecture as illustrated in Figure 1.

![Figure 1. Wrapper-like Edutella content provider integration architecture](image)

The key to the wrapper-like Edutella content provider integration architecture is ECDM (Edutella Common Data Model), which is shared by all metadata repositories and provides the common data view of the underlying metadata. At its basis, ECDM is a binary relational data model, which is defined in full compliance with the RDF data model and uses Datalog (Garcia-Molina et al., 2001) as its internal query language. Externally, Edutella defines a common query language: RDF-QEL (RDF Query Exchange Language) (Nilsson et al., 2003) to represent the query and query result. Taking ECDM as the unique interface, heterogeneous metadata repositories can be integrated into Edutella through different wrapper programs.
For each wrapper program, it has to accomplish two wrapper functionalities. First, it has to generate the ECDM-based common data view of underlying metadata. Second, it has to translate the RDF-QEL query into the local query languages, and vice versa, transform the local query result into the RDF-QEL query result. As RDF shares with ECDM/Datalog the central feature that their relational data models are based on sets of ground assertions conceptually grouped around properties, there exists a natural approach for the wrapper programs of RDF metadata repositories to generate the ECDM-based common data view, as well as to translate between RDF-QEL and local query languages based on Datalog (Nejdl et al., 2002). In contrast, for the wrapper programs of XML metadata repositories, it becomes difficult to achieve two wrapper functionalities.

Nowadays XML metadata repositories are principally supported by two XML query languages: XPath and XQuery. As XPath is relationally incomplete and incomparable to Datalog, for XPath-enabled XML metadata repositories, there exists no generic approach to integrating arbitrary XML schema based XML metadata repositories into Edutella (Qu et al., 2002a). However, for XQuery-enabled XML metadata repositories, as XQuery is much more powerful than XPath with regard to the transformation and expression capability, it becomes possible to integrate arbitrarily complex XML data schema based XML metadata repositories into Edutella through a generic integration approach. With the focus on E-Learning, in this paper we take a rather complex XML data schema: the SCORM XML binding as an example to present a generic approach for integrating XQuery-enabled XML metadata repositories into Edutella.

**Integrating XQuery-enabled SCORM XML Metadata Repositories into Edutella: Design Issues**

The SCORM is a model that references a set of interrelated technical specifications and guidelines with the purpose of achieving reusability, accessibility, durability, and interoperability of learning resources. The cornerstone of the SCORM is a Web-based learning “content aggregation model” defining how learning resources can be identified and described, aggregated into a course or portion of a course, and moved between different learning management systems or content repositories. In the latest SCORM 1.3, the SCORM content aggregation model is composed of four basic components (ADL, 2003):

- **SCORM content model**: Nomenclature defining the content components of a learning experience. Four types of defined components are Assets, SCA (Sharable Content Assets), SCO (Sharable Content Object), and Content Aggregation.
- **SCORM metadata**: A mechanism for describing specific instances of the components of the content model.
- **SCORM content packaging**: A mechanism defining how to represent the intended behavior of a learning experience (content structure) and how to package learning resources for the movement between different learning management systems (content packaging).
- **SCORM sequencing definition model**: A rule-based model defining how to sequence and deliver learning activities.

Among above four components, the key to the learning content discovery is the SCORM metadata, which provides descriptive information for each of the SCORM content model components to enable the discovery of learning resources at different aggregation levels. From the basis, the SCORM metadata information model is a reference to the IMS learning resource metadata information model, which itself is based on the IEEE LOM standard. In addition, the SCORM metadata also references the IMS learning resource metadata XML binding specification (IMS, 2001) and provides an XML representation for the SCORM metadata information data model. Throughout this paper we refer to the “SCORM XML metadata” as the XML representation of the SCORM metadata information model.

The SCORM XML metadata data model is rather complex, consisting of over 60 metadata entries and even recursive data structure, e.g., in the category of “classification”. While integrating XQuery-enabled SCORM XML metadata repositories into Edutella, we have to address several critical design issues.

First, there exists considerable incompatibility between the XML’s tree-like hierarchical data model and ECDM’s binary relational data model. In order to integrate XML metadata repositories into Edutella, we first need to design the XML representation of the ECDM-based common data view, whose underlying XML data model is compatible with the ECDM’s binary data model.

In practice, ECDM can be represented in the XML syntax in various ways. As the syntactic form of the XML data may strongly affect complexity and run-time performance of XQuery, we need to reasonably design the XML representation of the ECDM-based common data view. On the one hand, this XML-based common data
view should be interoperable with ECDM. On the other hand, it should also be able to easily be transformed from any arbitrarily complex XML data schemas by means of XQuery.

Second, XQuery and Datalog use different mechanisms to express the query. This makes it quite difficult to translate Datalog into XQuery as well as to transform local XML query results into RDF-QEL results while implementing the wrapper program for XQuery-enabled XML metadata repositories.

Whereas Datalog is a relationally complete query language that can express relational algebra in terms of the relational data model, XQuery is a functional query language in which a query is generally represented as an expression in terms of the XML’s tree-like data model. In most cases, Datalog queries cannot simply be represented through simple XQuery expressions, instead they usually have to be translated into sets of XQuery function calls. As the development of XQuery functions depends on individual XML data schema to be queried, in order to express the relational algebra and represent corresponding Datalog queries, we need to develop sets of XQuery functions based on the XML representation of the common data view. In addition, although the local XML query results returned by XQuery-enabled XML metadata repositories have already possessed an underlying data model that is compatible with ECDM, they still need some additional processing in order to be transformed into RDF-QEL results.

Third, As the SCORM XML metadata data model is rather complex, it is quite difficult to construct RDF-QEL queries for querying SCORM XML metadata repositories in Edutella.

Whereas for RDF metadata repositories the queries are always against a binary relational data model, for SCORM XML metadata repositories, the queries are against a tree-like hierarchical data model that possesses more than 60 metadata entries. For these metadata entries, as the user’s query interest is unforeseeable, we cannot expect which metadata entry would be queried and how the Boolean logics between these queries would seem. Including all metadata entries and all possible query Boolean logics in a form-like query GUI (Graphical User Interface) is a straightforward first idea, but can usually lead to some cumbersome and inefficient query experiences. Moreover, as the queries should uniquely be in the RDF-QEL format in Edutella, it becomes more complex for inexperienced users to construct RDF-QEL queries to query SCORM XML metadata repositories.

In order to address above design issues to integrate XQuery-enabled SCORM XML metadata repositories into Edutella, in this paper we propose a triple-like XML-based common data view to represent the ECDM data model, and a QBE (Query by Example) (Zloof, 1977) based SCORM query GUI to simplify the query construction process. As the key to the system design, the triple-like common data view can overcome incompatibility between the SCORM XML metadata data model and ECDM, and at the same time ensure XQuery’s run-time performance.

**Integrating XQuery-enabled SCORM XML Metadata Repositories into Edutella: Technical Implementation**

According to the wrapper-like Edutella content provider integration architecture, integrating XQuery-enabled SCORM XML metadata repositories into Edutella includes two major tasks. The first task is to manipulate SCORM XML metadata instances through XQuery to generate the triple-like XML-based common data view. This is actually the prerequisite for SCORM XML metadata repositories to be integrated into Edutella and sequentially be queried via ECDM’s internal query language Datalog. The second task is to develop the wrapper program for SCORM XML metadata repositories to accomplish two wrapper functionalities: (1) translating RDF-QEL into XQuery; and (2) transforming the local XML query result into the RDF-QEL result. As we have mentioned, in order to simplify the query construction process, we also have the third task: implementing the QBE-based SCORM query GUI.

**Generating the triple-like XML-based Common Data View**

The XML-based common data view is the XML representation of the ECDM data model. It should have two features. First, its underlying data model should be in full compliance with ECDM/RDF’s binary relation data model. Second, it should use a very simple XML syntax, which can easily be manipulated through XQuery to ensure the query’s run-time performance. In this paper we propose a triple-like XML-based common data view, which can be described in the XML DTD as:
For SCORM XML metadata repositories, the triple-like XML-based common data view can directly be generated through XQuery without the loss of any original SCORM XML metadata information. In order to present the generating process, we take a SCORM XML binding metadata entry: lom.general.catalogentry as an example. In Figure 2 we show the graphical data model of this metadata entry in the form of the XML Schema.

An example metadata instance of this metadata entry might seem as:

```xml
<?xml version="1.0" encoding="UTF-8"?>
<lom xmlns="http://www.imsglobal.org/xsd/imsmd_rootv1p2p1"
     xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
     xsi:schemaLocation="http://www.imsglobal.org/xsd/imsmd_rootv1p2p1
     http://www.imsglobal.org/xsd/imsmd_rootv1p2p1.xsd">
  <general>
    <catalogentry>
      <catalog>Blah</catalog>
      <entry>
        <langstring xml:lang="en">Blah EN</langstring>
        <langstring xml:lang="de">Blah DE</langstring>
      </entry>
    </catalogentry>
  </general>
</lom>
```

In order to generate the triple-like XML-based common data view, we re-describe the example SCORM XML metadata instance into an RDF graph through using RDF properties to represent XML elements. In Figure 3 we illustrate the RDF graph representing the example SCORM XML metadata instance.

In terms of the XML DTD of the triple-like common data view, the RDF graph can be serialized into the XML representation as illustrated in Figure 4. The serialization is realized through using a self-developed XQuery function library.
Figure 4. The XML serialization of the example SCORM XML metadata instance

While representing the SCORM XML metadata instance as the RDF graph, we try to follow the RDF model and syntax specification (Lassila et al., 1999) as much as possible. On the one hand, we make heavy use of anonymous resources as well as some RDF built-in properties such as `rdf:type` and `rdf:value`. On the other hand, we also try to remain compatibility with some popular metadata sets such as the DCMES, DCMI Metadata Terms (DCMI, 2003) and vCard, etc., in the representation. However, in spite of that, the triple-like common data view of SCORM XML metadata is not fully compatible with the IMS learning resource metadata RDF binding specification (IMS, 2001), which is usually viewed as the potential SCORM metadata RDF binding. In fact, the potential SCORM RDF binding is proposed without taking into account compatibility with the SCORM XML binding. It takes advantage of the semantic richness of RDF and goes beyond a simple syntactic level.
representation of the SCORM metadata information model, which makes it quite hard to transform SCORM XML binding metadata into potential RDF binding metadata without the loss of original metadata information. Therefore, while handling SCORM XML binding metadata, we should not expect 100% compatibility with the potential SCORM RDF binding.

Furthermore, we should also be aware that it is unnecessary to achieve full compatibility between the triple-like common data view of SCORM XML metadata and potential SCORM RDF binding metadata. From the syntactic view, the potential SCORM RDF binding uses several RDF built-in properties such as rdf:type in a rather ambiguous way, which might increase complexity and run-time cost of XQuery functions. While handling self-contained SCORM XML metadata, it is unnecessary for us to bear such sort of additional query overhead.

Nevertheless, we still tried to achieve the maximal compatibility between the triple-like common data view of SCORM XML metadata and potential SCORM RDF binding metadata with the purpose of handling SCORM XML and RDF metadata in a uniform way in Edutella. Some efforts include, e.g., using the same namespaces proposed in the potential SCORM RDF binding, remaining compatibility with DCMES, DCMI Metadata Terms and vCard in the triple-like common data view, etc. These efforts have actually covered most of principal design criteria of the potential SCORM RDF binding.

**Developing the Wrapper Program for SCORM XML Metadata Repositories**

The wrapper program of XQuery-enabled SCORM XML metadata repositories has to accomplish two wrapper functionalities: (1) translating RDF-QEL into XQuery; and (2) transforming local XML query results into RDF-QEL results. Since we adopt a triple-like common data view whose underlying data model is quite close to the ECDM/RDF’s binary relational data model, and also because XQuery is capable of returning query results in any desirable XML formats, the accomplishment of the second wrapper functionality is relatively straightforward. In this section our discussion will be focused on the implementation of the first wrapper functionality.

According to the Edutella content provider integration architecture, translating RDF-QEL into XQuery consists of two sub-tasks. First, RDF-QEL queries have to be translated into Datalog queries. This is a common task for all types of Edutella wrapper programs and can be completed through a common parser program in Edutella (Nejdl et al., 2002). Second, Datalog queries have to be translated into XQuery queries, more precisely, into sets of calls to the self-developed XQuery function library.

Datalog is a non-procedural, relationally complete query language based on Horn clauses without function symbols (Garcia-Molina, et al. 2001). As its counterpart, XQuery is also relationally complete and can perform all operations of relational algebra on XML’s tree-like data model including some complicated query operations such as the recursive query. In order to present the translation process from Datalog to XQuery, we illustrate an example Datalog query in Figure 5, which can be read in plain English as: find a SCORM XML metadata record, whose lom.general.title entry contains English value “computer” and lom.general.keyword entry contains English value “TCP”, or a SCORM XML metadata record, whose lom.general.description entry contains English value “Network”.

```plaintext
scorm(X) :- lom_gen:title(X,U), dc:language(U,"en"), rdf:value(U,"computer"),
          lom_gen:keyword(X,V), dc:language(V,"en"), rdf:value(V,"TCP")
scorm(X) :- lom_gen:description (X,W), dc:language(W,"en"), rdf:value(W,"Network")
? - scorm(X)
```

Here X,U,V,W are Datalog variables

**Figure 5. Example Datalog query**

One basic construct of Datalog is the Literal, which describes ground assertion and can be represented in a simplified form corresponding to the binary relational data model as: P(arg1, arg2), where P is Predicate that might be a relation name or arithmetic predicates (e.g., “<”, “>”, etc.), and arg1, arg2 are Arguments that might be variables or constants. A Datalog query can be expressed as a set of Datalog rules. Each Datalog rule has a general representation as head :- literal1, literal2,..., literaln, where head is a single positive Literal, and literal1 to literaln are a set of Literals conjunctively called the body of the Datalog rule. The disjunction in Datalog is expressed as a set of rules with the identical head. As illustrated in figure 5, the example Datalog query consists of two rules covering conjunctive and disjunctive query. It can be translated into sets of calls to the self-developed XQuery function library, as illustrated in Figure 6.
let $p := \text{query_on_element_with_langstring}\\("lom\_gen\_title","\","en","computer")
let $q := \text{query_on_element_with_langstring}\\("lom\_gen\_keyword","\","en","TCP")
let $r := \text{query_on_element_with_langstring}\\("lom\_gen\_description","\","en","Network")
return \text{handle\_Boolean\_OR}\\(\text{handle\_Boolean\_AND}(p \cup q) \cup r)\\)

Figure 6. XQuery query translated from the example Datalog query

The XQuery query is generally represented through the FLOWR (For-Let-Where-Order by-Return) expression, which generalizes select-from-having-where expression from SQL (Structure Query Language) and supports iteration and binding of variables to intermediate results. By means of the FLOWR expression, we can compute joins between different SCORM XML metadata records and further re-structure the query results. In our implementation, the self-developed XQuery function library contains sets of functions used to query different SCORM XML metadata entries. The returned query results are further handled by two specific XQuery functions: “handle\_Boolean\_OR” and “handle\_Boolean\_AND”, which are responsible for managing the Boolean logics between the queries against multiple metadata entries. These two XQuery functions can also eliminate duplicate local XML query result sets.

Implementing the QBE-based SCORM Query GUI

QBE is a graphical language originally designed for querying RDBs. The idea behind QBE is that the user provides an example of outputs that he expects from the query and constructs the query by filling example tables (Zloof, 1977). Whereas QBE fits well with RDBs in that QBE’s tabular query interface is quite analogous to the internal tabular structure of RDBs, it cannot directly be used to query native XML metadata repositories, which, as the document databases by nature, adopt tree-like hierarchical data models to store XML metadata. In order to query SCORM XML metadata repositories in Edutella, we propose an improved QBE, which uses a visual template to represent the query against individual XML metadata entry, and further adopts a single table to represent the Boolean logics between multiple visual templates. While the visual template provides a quite analogous representation of the internal structure of individual XML metadata entry, the single tabular structure inherits QBE’s original forte for representing the Boolean logics between queries.

According to above design idea, we implement the QBE-based SCORM query GUI that can be used to query SCORM XML metadata repositories in Edutella in the RDF-QEL syntax. The QBE-based SCORM query GUI has four features:

- Arbitrary SCORM XML metadata entry could be taken as the “query example”.
- User-friendly drag & drop manipulation based on the SCORM XML binding DOM (Document Object Model) tree.
- Automatic RDF-QEL output.
- Integration of the graphical RDF-QEL result presentation.

In Figure 7 we show a screen shot of the QBE-based SCORM query GUI, which demonstrates the construction process of the example query illustrated in figure 5/figure 6.

Figure 7. QBE-based SCORM query GUI

In the QBE-based SCORM query GUI, the user can first choose SCORM XML metadata entries to be queried from the SCORM XML binding DOM tree through drag & drop manipulation. The user can then compose sets of visual templates corresponding to different SCORM XML metadata entries in a table according to the expected Boolean logics between the queries. The output of the SCORM query GUI is RDF-QEL queries. These
RDF-QEL queries can then be sent to the Edutella network and are expected to get query results from all SCORM XML metadata repositories.

Conclusions

Acknowledging the inherent advantages of RDF such as easy compositability of schemas, extendability and modularity of distributed RDF metadata, etc., Edutella adopts a fully RDF-based design to manage learning resource metadata, aiming to become part of the future Semantic Web. Still, we do want to use large amounts of XML-based learning resource metadata, which have been produced in E-Learning in the last years and are still populating today. In this paper we present our exploration to integrate XQuery-enabled SCORM XML metadata repositories into Edutella. Actually, the integration approach is not merely applicable to XML-based learning resource metadata in Edutella. It can be extended as a generic approach for managing arbitrary XML metadata in any RDF-based Semantic Web settings.

References


Inferring Metadata for a Semantic Web Peer-to-Peer Environment

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Abstract
Learning Objects Metadata (LOM) aims at describing educational resources in order to allow better reusability and retrieval. In this article we show how additional inference rules allows us to derive additional metadata from existing ones. Additionally, using these rules as integrity constraints helps us to define the constraints on LOM elements, thus taking an important step toward a complete axiomatization of LOM metadata (with the goal of transforming the LOM definitions from a simple syntactical description into a complete ontology). We will use RDF metadata descriptions and Prolog as an inference language. We show how these rules can be applied for the extensions of course metadata using an existing test bed with several courses. Based on the Edutella peer-to-peer architecture we can easily make RDF metadata accessible to a whole community using Edutella peers that manage RDF metadata. By processing inference rules we can achieve better search results.

Keywords
Metadata, Peer-to-peer network, Inference rules, E-Learning

Motivation

Metadata for Learning Resources

At universities an increasing amount of electronic supplemental resources are available or under development for various curricular activities. These can be small modular resources like animations or video sequences or complete courses. To access these learning resources efficiently and to create innovative services and intelligent applications these resources must be described comprehensively with metadata. For this purpose several metadata standards are available.

The Dublin Core (DC) element set defines a set of 15 basic metadata elements such as Title, Creator, Subject or Description, confer the Dublin Core homepage (http://www.dublincore.org) for more details. In the domain of education the most important metadata standard is Learning Objects Metadata LOM (http://lisc.ieee.org/wg12/index.html), which has been standardized by the IEEE. LOM comprises 45 elements that are categorized into the nine categories General, Life Cycle, Meta-Metadata, Technical, Educational, Rights, Relation, Annotation and Classification.

At the Institute for Communications Technology, Braunschweig Technical University, Germany, and the Information Systems Institute, Hannover University, Germany, several electronic courses have been developed in previous projects. As test beds for educational research projects the two courses Signal Transmission II (http://www.ifn.ing.tu-bs.de/sue/) and Artificial Intelligence (http://www.kbs.uni-hannover.de/Lehre/KI1/WS02/) have been annotated with a subset of both Dublin Core and LOM metadata. The metadata elements have then been encoded in RDF (Resource Description Framework) and RDF Schema (cf. http://www.w3c.org/RDF), making them accessible in Edutella, an innovative peer-to-peer (P2P) architecture for...
the exchange of educational resources cf. (Nejdl, et. al., 2002). For a detailed description on how to use RDF to annotate a course with metadata see “Annotation for an open learning repository for computer science - case study & OLR3 editor” (Brase & Nejdl, 2003).

To access specific content of a given course requires that all resources are (in addition to trivial metadata elements such as title, creator, description,…) accurately described by structural relationships and relationships in terms of logical sequences of content. This has been achieved using the Dublin Core qualifiers has Part, has Version and so on.

Single course assets have been classified using domain-specific taxonomies. For the computer science domain the ACM CCS classification (http://www.acm.org/class/1998/) and for the engineering domain the Engineering Index EI classification (http://ecls.lub.lu.se/) have been used. Both classification schemes have been coded in RDF for machine-readability (http://www.kbs.uni-hannover.de/Uli/ACM_CCS.rdf and http://www.ifn.ing.tu-bs.de/tv/painter/ecls/ecls.rdf). The ACM classification has been refined in certain taxons to allow a more precise characterization of the topic of course elements.

Problem Description

The motivation in describing the courses with LOM metadata was to achieve better retrieval results when searching for educational content and to allow more precise queries. During annotating complete courses consisting of a set of related resources, it was obvious that several metadata fields are implicit for certain resources in that they can be easily derived from the fields of other resources. For example some metadata elements are simply inverse attributes to other ones: The qualified relationship has Part between two resources implies the inverse relationship is Part Of where RDF subject and object are interchanged (i.e. the directed RDF arc between both is reversed). With the help of a set of logical rules, which can be processed by an inference engine, all these implicit metadata elements or RDF statements can be created automatically from the existing ones and added to get complete annotations.

Another point to notice is that the specifications for the LOM data model are mainly on the syntactical level, but leave out important semantical information. What is needed here are axioms (we can use the inference rules mentioned above as integrity constraints) which provide a formal basis for a more precise description of the usage of all LOM elements. One example is the is Part Of relationship between two resources. In our definition this relationship describes the hierarchical structure in terms of course modules. However, one could use an is Part Of qualifier in terms of a temporal relationship. The usage of this relationship changes the axioms for this attribute dramatically.

Adding axioms is therefore an important means for creating a shared semantical basis for metadata elements usage and thus clarifying how to use the LOM metadata elements. By that the exchangeability of LOM metadata records between different applications is increased.

Ontologies, which have recently got a lot of attention in the context of the Semantic Web, provide a shared and common understanding of a domain that can be communicated between people and application systems like agents. They are developed to facilitate knowledge sharing and reuse cf. (Fensel, 2001). In the simplest case, an ontology describes a hierarchy of concepts related by relationships cf. (Guarino, 1998). In a more sophisticated ontology, suitable axioms are added in order to express other relationships between concepts and to constrain their intended interpretation.

In this context we start from a comprehensive though not complete description of learning resources by metadata elements. These metadata elements not only use attributes to express keywords and creator information but also provide a specific model of our course in terms of (hierarchical) structure. By processing the axioms not only the metadata annotations can be completed by implicit metadata as described above. Additionally these axioms help checking the semantical consistency with regards to the intended interpretation.

Inference Rules and Axioms for a Formal Description of LOM

As a result of the annotation process a set of inference rules have been defined, which have been included in a recently published paper (Brase, Painter & Nejdl, 2003). In this section only a few rules will be described using first-order logic for simplicity. Other languages like Prolog or TRIPLE can be used similarly.
Rules

In the following rules, $R, R_1, \ldots$ are being used as an abbreviation for learning resources. The metadata attributes from `dcterms` that define relations between resources as `dcterms:hasPart`, `dcterms:hasVersion`, etc. play an important role in the annotation, because most of our inference rules are especially useful when relations between learning resources are taken into account. In the following, `attribute`, `attribute_1`,... are being used as a placeholder since many of the rules work for different attributes.

**Inverse Attributes:** The most basic rule describes the fact that some attributes have inverse attributes. If there is a `dcterms:hasPart` relationship between two resources $R_1$ and $R_2$, than there has to be also a `dcterms:isPartOf` relationship between $R_2$ and $R_1$. The rule is defined in first-order logic as:

$$
\forall R_1, R_2, attribute_1, attribute_2:

(attribute_2(R_2, R_1) \land inverse(attribute_1, attribute_2))
\Rightarrow attribute_1(R_1, R_2)
$$

$$
\forall attribute_1, attribute_2 : inverse(attribute_1, attribute_2)
\Rightarrow inverse(attribute_2, attribute_1)
$$

**Transitive Attributes:** Transitivity occurs with the attributes `dcterms:hasPart` and `dcterms:isPartOf`. If a resource $R_1$ includes a part $R_2$ and $R_2$ in turn includes a part $R_3$, then it can be inferred that $R_1$ includes part $R_3$. The rule defined in first-order logic is:

$$
\forall R_1, R_2, R_3, attribute:

(attribute(R_1, R_2) \land attribute(R_2, R_3) \land transitive(attribute))
\Rightarrow attribute(R_1, R_3)
$$

**Inheritance:** Predicates can be inherited along certain attributes. As the attribute `dcterms:hasPart` and `dcterms:isPartOf` are used to structure a course, a lot of predicates like 1.3 Language, 1.5 Keyword, etc. can be inherited from a lecture unit to the whole lecture, expressed via the following inference rule:

$$
\forall R_1, R_2, attribute, predicate, value:

(attribute(R_1, R_2) \land (predicate(R_2, value) \land inheritance_along(attribute, predicate)))
\Rightarrow predicate(R_1, value)
$$

**Inference Rules for Content Classification**

To classify the content of a learning object the IMS binding guide (http://kmr.nada.kth.se/el/ims/metadata.html) suggests to link the attribute `dc:subject` to an ontology that is available as an RDF file in the internet and is structured using the attribute `lom cls:taxon` for the topic – subtopic relationship (For detailed description about the use of ontologies for the content classification of learning resources see “Ontologies for eLearning” (Brase & Nejdl, 2003). If this semantic structure can also be accessed by an inference engine, we can formulate the following rule to infer that a resource that covers a topic also covers all subtopics.

$$
\forall R, content_1, content_2:

(dc\_subject(R, content_1) \land (lom\_cls\_taxon(content_1, content_2)))
\Rightarrow dc\_subject(R, content_2)
$$

**Usage of inference rules in a Metadata Environment**

In the context of the Edutella-project we have started to annotate courses with metadata. Though the courses usually differ in the kind and amount of learning materials they use, their use of learning resources is surprisingly homogeneous. The average course is divided in 6 to 7 units or knowledge modules which themselves can be split into 3 to 7 learning resources. This leads to an average number of about 35 learning resources per course, with a learning resource being the slides of the lecture, a video or any other set of pages dealing with one subject. IN the first version of Edutella we annotated mainly the technical aspects of the
resources. Therefore we defined a best-practice subset of 17 elements which is summarized in the following table, using the categories defined in LOM, extended by the rules we can use for this attribute. For the complete overview of these rules, we refer to the paper (Brase, Painter & Nejdl, 2003).

<table>
<thead>
<tr>
<th>LOM category</th>
<th>Metadata name</th>
<th>used attribute</th>
<th>Rules</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. General</td>
<td>1.2 Title</td>
<td>dc:title</td>
<td>none</td>
</tr>
<tr>
<td></td>
<td>1.3 Language</td>
<td>dc:language</td>
<td>inheritance_along (dcterms:hasPart,Language).</td>
</tr>
<tr>
<td></td>
<td>1.4 Description</td>
<td>dc:description</td>
<td>inheritance_along (dcterms:hasPart,Description).</td>
</tr>
<tr>
<td>2. Lifecycle</td>
<td>2.3 Contribute</td>
<td>dc:creator</td>
<td>inheritance_along (dcterms:hasPart,Entity).</td>
</tr>
<tr>
<td></td>
<td></td>
<td>with a lom:entity and the author in vCard format dcq:created with the date in W3C format</td>
<td>inheritance_along (dcterms:hasPart,Date).</td>
</tr>
<tr>
<td>5. Educational</td>
<td>5.2 Learning Resource Type</td>
<td>rdf:type</td>
<td>inheritance_along (dcterms:hasPart,Type).</td>
</tr>
<tr>
<td>6. Rights</td>
<td>6.3 Description</td>
<td>dc:rights</td>
<td>inheritance_along (dcterms:hasPart,Entry).</td>
</tr>
<tr>
<td>7. Relation</td>
<td>dcq:requires</td>
<td></td>
<td>inverse(dcterms:hasFormat, dcterms:isFormatOf).</td>
</tr>
<tr>
<td></td>
<td>dcq:isFormatOf</td>
<td></td>
<td>inverse(dcterms:hasPart, dcterms:isPartOf).</td>
</tr>
<tr>
<td></td>
<td>dcq:isPartOf</td>
<td></td>
<td>inverse(dcterms:requires, dcterms:isRequiredBy).</td>
</tr>
<tr>
<td></td>
<td>dcq:hasVersion</td>
<td></td>
<td>inverse(dcterms:hasVersion, dcterms:isVersionOf).</td>
</tr>
<tr>
<td></td>
<td>dcq:requires</td>
<td></td>
<td>outwardInheritance_along (dcterms:hasPart, dcterms:requires).</td>
</tr>
<tr>
<td></td>
<td>dcq:isRequiredBy</td>
<td></td>
<td>inverseInheritance_along (dcterms:hasFormat, dcterms:requires).</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>outwardInheritance_along (dcterms:hasVersion,dcterms:requires).</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>transitive(dcterms:hasPart).</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>transitive(dcterms:isPartOf).</td>
</tr>
<tr>
<td>9. Classification</td>
<td>dc:subject</td>
<td>for content classification. This attribute links to an entry in a hierarchical ontology, that is an instance of lom cls:Taxonomy</td>
<td>inheritance_along (dcterms:hasPart,Entry).</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>inverseInheritance_along (dcterms:hasFormat,Entry).</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>inheritance_along (dcterms:hasVersion,Entry).</td>
</tr>
</tbody>
</table>

These attributes lack however most educational aspects of the resources. We will deal with the educational aspects in a subsequent version of Edutella. The annotations of one whole course can be included in a single RDF file. Some querying tools like the Edutella peer discussed in the next section allow querying over the RDF file, using the RDF query language RDQL (cf. the RDQL-Homepage: http://www.hpl.hp.com/semweb/rdql.htm for more details).

**Inferring over Metadata with PROLOG**

Metadata can easily be transferred to Prolog. The Metadata-statement:

The author of a resource http://www.xyz.com is “Peter Smith”

Can be stored as

(if we use the Dublin Core attribute for authors).

A inheritance along dcterms:hasPart inference rule for the attribute author can than be written in Prolog as:

\[
\text{rdf}(\text{dc}_\text{creator}, \text{Resource}_2, \text{Value}) :- \\
\text{rdf}(\text{dc}_\text{creator}, \text{Resource}_1, \text{Value}), \\
\text{rdf}(\text{dcterms}_\text{hasPart}, \text{Resource}_1, \text{Resource}_2), \\
\text{inheritance}_\text{along}(\text{dcterms}_\text{hasPart}, \text{dc}_\text{creator}).
\]

To use our inference rules, we have decided to write an inference machine in PROLOG. We developed an RDF-PROLOG-Parser, based on Minerva, a ISO-13211-1 Prolog compiler and executive hosted in Java. Using this inference machine we were able to create new expanded RDF files for each course. Extended with the implicit information about the course material, querying this files enhanced our query results, when searching in the context of the Edutella project.

**Querying Course Descriptions Using Edutella File-based Peers**

The Edutella network provides a peer-to-peer infrastructure for educational materials annotated with RDF. The following gives an overview of how the data in Edutella is stored and how the information can be queried. We conclude this with an example setup to show how annotated course material can be published and queried within the network.

In our context a peer is a computer that stores RDF metadata descriptions of courses. It is also called provider peer or provider from here. A consumer is a peer that sends queries to the network and retrieves the results from the provider peers. It normally has some kind of user interface to define queries (cf. Fig. 2).

Edutella is based on the JXTA framework. JXTA is an Open Source project supported and managed by Sun Microsystems. In essence, JXTA is a set of XML based protocols to cover typical P2P functionality. It provides a Java binding offering a layered approach for creating P2P applications. In addition to remote service access (such as offered by SOAP), JXTA provides additional P2P protocols and services, including peer discovery, peer groups, peer pipes, and peer monitors. Therefore JXTA is a very useful framework for prototyping and developing P2P applications. For further information about the JXTA project we refer to The JXTA Project Homepage (http://jxta.org).

For storing and exchanging information in the Edutella network a data model was introduced (ECDM). This data model allows the description of all query-information in the language QEL. This ECDM/QEL queries can be converted to different provider query languages e.g. SQL, RDQL, Google, OLR, Figure 1 illustrates this.

![Figure 1: Query Processing in Edutella](http://example.com/edutella.png)

The consumer interface allows the user to build a query which is then parsed into the QEL/ECDM. The query is sent to the peers in the network. Providers convert the QEL query back into their native query language, e.g. SQL or RDQL.

We use a file-based provider to publish course metadata in our testbed. This provider is based on a knowledge base which consists of files containing all RDF metadata descriptions for the course material. Currently, we support RDQL to query this knowledge base.
Figure 2 shows a query resultset based on a course in artificial intelligence. As mentioned above, we use the ACM-CCS to classify the content of a learning resource. The search in this example was for the metadata entry “dc:subject: I.2.8.0” (standing for “I. Computing Methodologies / ARTIFICIAL INTELLIGENCE / Problem Solving, Control Methods, and Search / Backtracking” in the ACM classification). The result is a single learning resource with no author annotated because there is only one author information for the complete course.

![Query results on non-inferred metadata](image)

Querying the RDF files that were extended using our inference rules, the file-based provider offers a different result set shown in Figure 3.

Not only the learning resource is a result, but also the unit and the course it belongs to, because the content information is inherited upward, following the fact that if a learning resource in a course has the subject “Backtracking”, the complete course has the subject “Backtracking”. Also the resource has inherited the author information from the course.

**Conclusion and Further Work**

In this article we have shown how inference rules can help us with our usage of metadata. We have focussed on the querying of learning resources in a P2P environment, but these rules also help us in the creation of metadata course description. We also gain a formal description for the elements of the metadata-standard LOM.

We have introduced you to the P2P infrastructure Edutella, we use to access learning objects. Using an inference machine based on Prolog with an import and export functionality to RDF we are able extend metadata descriptions of learning objects inside Edutella, gaining better search results.

We are currently working on a tool for semi-automatic course annotation, that will decrease the number of explicit metadata attributes that have to be edited by hand, using this inference rules.
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On enhancing on-line collaboration using fuzzy logic modeling

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Abstract

Web-based collaboration calls for professional skills and competences to the benefit of the quality of the collaboration and its output. Within this framework, educational virtual environments may provide a means for training upon these skills and in particular the collaborative ones. On the basis of the existing technological means such training may be enhanced even more. Designing considerations towards this direction include the close follow-up of the collaborative activity and provision of support grounded upon a pedagogical background. To this vein, a fuzzy logic-based expert system, namely Collaboration/Reflection-Fuzzy Inference System (C/R-FIS,) is presented in this paper. By means of interconnected FISs, the C/R-FIS expert system automatically evaluates the collaborative activity of two peers, during their asynchronous, written, web-based collaboration. This information is used for the provision of adaptive support to peers during their collaboration, towards equilibrium of their collaborative activity. In particular, this enhanced formative feedback aims at diminishing the possible dissonance between the individual collaborative skills by challenging self-adjustment procedures. The proposed model extents the evaluation system of a web-based collaborative tool namely Lin2k, which has served as a test-bed for the C/R-FIS experimental use. Results from its experimental use have proved the potentiality of the proposed model to significantly contribute to the enhancement of the collaborative activity and its transferability to other collaborative learning contexts, such as medicine, environmental engineering, law, and music education.

Keywords

Fuzzy logic in CSCL, Evaluation of e-collaboration, On-line collaborative skills, Fuzzy logic in Lin2k, Music e-education

Introduction

Web-based collaboration is currently the focus of considerable interest, as it reveals new opportunities that make online joint work a realistic option for distributed workgroups. The participants, however, in this work holding divergent characteristics, need to possess collaborative skills to sustain the quality of the collaborative procedure. While many virtual educational collaborative environments appear to facilitate and support various facets of online collaboration, the definition of support here is restricted to the enhancement of the collaborative skills, independently of the task of the collaboration.
As far as the various derivation mechanisms is concerned, which have been used to provide evaluative inferences upon the logged raw data, they include, counting, social networks, matching group interaction ‘patterns’, activity recognition, Hidden Markov Models, finite state machines, rule-based expert system, decision trees, reviewed in (Jermann et al., 2001; Soller et al., 2000), machine learning, Bayesian networks, and fuzzy logic, reviewed in (Beck et al., 1999). Unlike the aforementioned modeling technologies, fuzzy logic provides a means for mapping available information (in terms of linguistic descriptions) to vague categories and conducting inference processes without employing precise quantitative analyses (Zadeh, 1965). Fuzzy logic-based educational applications include (Abou-Jaude et al., 1999; Kosba et al., 2003; Barros et al., 1999). In particular, Barros et al., introduced a fuzzy logic-based expert system to evaluate the participants’ collaborative activity. The development of such a model was based upon the linguistic descriptions of its structure provided by the domain expert, by means of a set of variables. A weighting system was used to relate the logged raw data (interactions) to the above variables, which, in turn, define the quality of the collaborative activity (Dillenbourg et al., 1996). This procedure was also carried out, yet manually, in terms of human intervention to the elaboration of the inferences in a web-based collaborative tool, namely Lin2k (Hadjileontiadou et al., 2003). However, unless the number of variables is kept small and the weights fixed, this approach may result in a heavy workload in a large-scale use of Lin2k.

In this paper, a fuzzy logic-based inference system, namely Collaboration/Reflection-Fuzzy Inference System (C/R-FIS), is presented. It has been drawn upon the models introduced in (Hadjileontiadou et al., 2003; Barros et al., 1999) to develop an alternative perspective for the enhancement of computer-supported collaboration. At a first level, the C/R-FIS model extents the Lin2k evaluation system (Hadjileontiadou et al., 2003) by introducing more variables, better fine tuning of the weights, and automation of the evaluation procedure, based on processing of collaborative and metacognitive data. The latter are generated during the peers’ collaboration and recorded by the Lin2k interface (Hadjileontiadou et al., 2003). It must be noted that, despite the use of the Lin2k interface for acquiring the collaborative data, the employment of the C/R-FIS extends the evaluation part of the Lin2k, due to the employment of the fuzzy-logic perspective. Moreover, it introduces a more efficient version of the
Collaboration-Fuzzy Inference System (C/FIS) model (Hadjileontiadou, in press), which constitutes a pilot attempt to model only the collaborative data. The C/R-FIS model, by adopting a holistic framework for the evaluation of each individual’s collaborative activity at cognitive and metacognitive level, takes into account the total activity that is performed by the peers’ social construct in the evaluation procedure (Salomon et al., 1998). At a second level, the proposed C/R-FIS model extends the set of evaluation variables employed in (Barros et al., 1999), and materializes the equilibrium approach, as far as the evaluation of the quality of the peers’ collaborative activity is concerned. More specifically, as the collaboration progresses, indicators of each peer’s collaborative activity are dynamically updated, encouraging the peers to improve within the group. Thus, the C/R-FIS model focuses on the peers’ social construct, i.e., at the group level, with a more refined perspective as compared to the aforementioned works.

The paper is organized as follows. In Section 2, a short description of Lin2k is provided. The proposed C/R-FIS system is introduced in Section 3, whereas in Section 4, implementation and experimental issues are reported and discussed. Finally, Section 5 concludes the paper.

Background Information

Lin2k is a web-based tool for asynchronous, written collaboration between two peers, i.e., \( n = A, B \). These peers collaborate to produce a report, on the problems that are posed by a case study from a domain of interest. This report is gradually produced during successive sessions of collaboration, namely steps \( s \). Moreover, Lin2k supports the experiential learning of ‘proper’ collaboration, towards a balanced quality of the peers’ collaborative activity, in order to produce the best dynamic of the pair under consideration. To this direction, self-regulation is challenged through follow-up of each peer’s interactions, evaluation of his/her collaborative activity, and feedback provision, as follows.

Each peer participates in the collaboration using his/her individual workspace, which holds the semi-structured area as depicted in Figure 1. By means of this communication model s/he submits certain types of contribution \( CB_i \), \( i = 1: 7 \) (Hadjileontiadou et al., 2003), as presented in Table 1. It is noteworthy that these individual workspaces provide a frame for text editing, without imposing any restrictions on its syntax as other semi-structured interfaces do, i.e., interfaces where a sentence-opener based chat style is provided (Soller et al., 1999). Moreover, Lin2k users are engaged in the process of categorization of their contributions by means of specific buttons corresponding to each type of contribution (see Figure 1). This classification is a conscious procedure as opposed to other semi-structured interfaces, e.g., sentence openers that upon their use are assigned to specific communication categories of which the student is ignorant. The Lin2k system by means of mouse clicks, logs every \( CB_i \) per step and user, archiving data at the task level. The peers, using the above described communication protocol, may shift at will to a parallel written dialogue concerning the co-ordination of their collaborative activity related to the examined case study. Hence, further collaborative data is being logged as previously described, namely data at the co-ordination level. Common sight interfaces display the threaded discussions at both levels to facilitate their development.

![Figure 1: The communication model integrated within the individual workspace](image)
Evaluation of each peer’s collaborative activity, at both the task and the co-ordination level, takes place by means of four variables \( j = 1: 4 \), which are depicted in Table 1. Their value is the sum of the weighted \( CB_i \)s by the empirically defined weights \( w_{ij} \) and \( a_j^{\text{m}} \) (Hadjileontiadou et al., 2003) per level (see Table 1). The sum for all variables and levels provides the total collaborative activity for each peer. This sum is normalized to the total pair collaboration activity, to give the percentage of each peer’s contribution to it, namely \( C_i^*, n = A, B \). In this way, the latter values range from 0 to 100% and are complementary. Significant divergence of these complementary values, i.e., \( C_s^* = 20 \text{, } C_n^* = 80\% \), is indicative of a low collaboration quality, whereas, convergence to equality, i.e., \( C_s^* = C_n^* = 50\% \), indicates high collaboration quality. A preferable area of convergence of the \( C_i^* \) values in the collaboration plane, namely Balanced Collaborative Activity zone (BCA), is defined between 40-60% of the collaboration quality. By the end of each \( s \) step, the Lin2k interface previews to each peer the BCA zone along with his/her \( C_i^* \) value, to stimulate reflection upon the preceded collaborative activity.

### Table 1: Educational modeling (Hadjileontiadou et al., 2003)

<table>
<thead>
<tr>
<th>Contribution type</th>
<th>a) Weights ( w_{ij} ) (common for the task and co-ordination level)</th>
</tr>
</thead>
<tbody>
<tr>
<td>( i )</td>
<td>( j=1 )</td>
</tr>
<tr>
<td>Proposal</td>
<td>10</td>
</tr>
<tr>
<td>Contra proposal</td>
<td>10</td>
</tr>
<tr>
<td>Comment</td>
<td>4</td>
</tr>
<tr>
<td>Clarification</td>
<td>4</td>
</tr>
<tr>
<td>Agreement</td>
<td>1</td>
</tr>
<tr>
<td>Low level questions</td>
<td>4</td>
</tr>
<tr>
<td>High level questions</td>
<td>7</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Contribution type</th>
<th>b) Relevant significance of the variables per level</th>
</tr>
</thead>
<tbody>
<tr>
<td>( j )</td>
<td>Task level ( a_j^{\text{m}} )</td>
</tr>
<tr>
<td>1</td>
<td>0.3</td>
</tr>
<tr>
<td>2</td>
<td>0.3</td>
</tr>
<tr>
<td>3</td>
<td>0.2</td>
</tr>
<tr>
<td>4</td>
<td>0.2</td>
</tr>
</tbody>
</table>

Further on, and before entering the next step, a web form is presented to each peer. It contains \( K \) terms related to ‘proper’ collaboration, expressed as declarative statements. The peer, having realized his/her deficiencies, is asked to ‘tick’ those terms that correspond to particular aspects of his/her collaboration activity within the group that he/she intends to improve at the next step. The system again collects data, in terms of mouse clicks, from this metacognitive activity (Webb et al., 1995), to calculate the Improvement Cost, \( R_i^* \). The \( R_i^* \) value is a percentage, ranging from 0% (no statement was checked, hence no improvement is required) to 100% (all statements were checked, hence total improvement is required).

The Lin2k feedback model aims at the converging of each peer’s collaborative activity to the BCA zone through self-adjustment procedures. To this end, before exiting \( s \) step and prior beginning the next step, \( s, s + 1 \), of the case study, it presents a message to each peer, which may be either of an encouraging character (to sustain the quality of his/her collaborative activity), or of an adjusting one (like a warning message). The latter is provided when the peer’s performance is in contradiction to his/her self-evaluation on the basis of the comparison between the \( C_i^* \) and \( R_i^* \) values. A more detailed description of Lin2K can be found in (Hadjileontiadou et al., 2003).

### The proposed C/R-FIS model

The proposed C/R-FIS model produces evaluation inferences upon the data that are logged by the Lin2k interfaces, as previously described. Yet, it automates Lin2k evaluation system and, moreover, by means of an increased number of variables employed, it outputs an enhanced form of the \( C_i^* \) and \( R_i^* \) values, namely \( eC_i^* \)
and $eR^*_r$, respectively. In particular, it constitutes a model of the domain-expert’s evaluating system. Such modeling, however, requires the knowledge of the system structure and function, and the adoption of appropriate mathematical tools. When the system is complicated or ill-defined, conventional functions cannot be used to model it. A domain-expert, however, could provide the required knowledge, using the natural language. In such cases, the fuzzy logic technology, introduced by Zadeh (1965), allows modeling of the system on the basis of the expert’s linguistic descriptions of it. Moreover, it allows the representation of these descriptions through analytical forms at the mathematical level, where computations take place. In the case of structuring the proposed evaluating system, the domain expert is the evaluator (teacher). On the basis of the above, the C/R-FIS model is a FIS of the Mamdani type (Zadeh, 1965).

Fuzzy logic modeling is based on linguistic descriptions in the form of IF/THEN rules, which can be expressed by the domain expert. The IF/THEN implication operator defines two parts in the rule, the left-hand side (LHS) and the right-hand side (RHS) (Tsoukalas, 1997). In our case, an example of such rule could be:

‘IF the initiative is satisfactory AND (OR) the creativity is low THEN collaboration is low’.

Apart from the linguistic form, the rules possess an analytical background, as well (Tsoukalas, 1997). The arguments of the linguistic variables, e.g., ‘initiative’, ‘creativity’, are fuzzy values, e.g., ‘low’, ‘satisfactory’. The analytical evaluation of the fuzzy proposition, e.g., ‘initiative is satisfactory’, is performed through a membership function (mf) that models the fuzzy value ‘satisfactory’. It maps every crisp value of the universe of discourse of ‘initiative’ to a fuzzy number in the interval [0,1], where 0 denotes no membership to the fuzzy value, whereas 1 denotes total membership to the fuzzy value (Wang, 1997). This approach allows infinite degrees of membership between 0 and 1 to be possible, resulting in a more flexible representation of the word ‘satisfactory’ from the linguistic to the analytical form. The shape of the mf varies according to the expert’s definition, on the basis of application specific criteria (Tsoukalas, 1997). When the input data is introduced to the FIS, the fuzzy numbers that result by the above fuzzification procedure at the LHS of the rule are combined through union or intersection, according to the AND/OR operators, to produce a new fuzzy number. When the LHS of a rule is satisfied, the rule is activated (fired) and then, through the IF/THEN implication operator, clipping is performed to the mf of the RHS of the rule. The ELSE operator aggregates the remainder mf areas from all the rules, to produce an area-output of the fuzzy inference procedure. By means of a defuzzification method (Tsoukalas, 1997), the equivalent to the above area crisp output, i.e., the $eC^*_r$ or the $eR^*_u$ value is calculated.

Evaluative inference by means of many variables increases the validity of the decision; yet, in parallel, it increases the difficulty for the expert to express the evaluative rules. To overcome this contradiction, an inference scheme of successive levels of FISs is adopted (Barros et al., 1999). According to this approach, the estimated output of a FIS serves as input to the FIS of the next level, resulting in a unified inference model. Under this perspective, the C/R-FIS model materializes two inference schemes for the calculation of the $eC^*_r$ and $eR^*_u$ values, as depicted in Figures 2(a), and (b), respectively. Each scheme functions upon an enhanced number of variables, as compared to the so far used in Lin2k. Their values are either elaborated logged data, i.e., primary variables ($PV^*_v$,), or inferred, i.e., intermediate variables ($IV^*_v$), $n = A, B, q = 1:5$ (see Figure 2).

![Figure 2](image-url)

**Figure 2:** $PV^*_v$ and $IV^*_v$ variables of the C/R-FIS model.
At the inference scheme, the $PV_{n,m}^{e}$, $n = A,B$, $m = 1:8$, values serve as initial inputs and denote each peer’s contribution to the respective pair-work. Their calculation takes place upon the raw collaborative data that are logged by the system, by means of the variables $(j = 1:4)$ and the weights $(w_{n})$ that were used in Lin2k (see Table 1). Yet, unlike the Lin2k data elaboration, four more variables are being introduced (see the variables for $m = 5:8$ in Figure 2(a)). Moreover, the relative significance of the variables per level, instead of being considered by the empirically defined weights $a_{n}^{e}$ and $a_{m}^{e}$ (see Table 1), is refined through the FISs’ rules. In particular, the following computations take place.

Let $TCB_{n,i}^{e}$ and $TCB_{i}^{n}$ be the total number of each contribution type $CB_{n}, i = 1,...,7$; the $PV_{n,m}^{e}$ values are given by (see Table 1 and Figure 2):

$$PV_{n,m}^{e} = \frac{X_{n,m}^{e}}{X_{n,m}^{e} + X_{n,m}^{e}}, \quad m = 1:8,$$

where:

$$X_{n,m}^{e} = \sum_{j=1}^{7} \sum_{i=1}^{4} TCB_{n,i}^{e} \cdot w_{n,i}^{j}, \quad m = 1:4$$

$$X_{n,m}^{e} = \sum_{j=1}^{7} TCB_{n}^{e},$$

$$X_{n,m}^{e} = \sum_{j=1}^{7} (TCB_{n}^{e} \cdot w_{n,j}^{j} + TCB_{n}^{e} \cdot w_{n,j}^{j}),$$

$$X_{n,m}^{e} = \sum_{j=1}^{7} TCB_{k}^{e},$$

$$X_{n,m}^{e} = \sum_{j=1}^{7} TCB_{k}^{e}.$$

At the inference scheme, unlike the partial calculation of the $R_{n}$ value, the $PV_{n}^{e}$, $\lambda = 1:5$ variables are introduced (see Figure 2). Empirically defined weights $w_{n,i}$ (Hadjileontiadou et al., 2003) weight the $K$ terms of the web-form to the above variables. In this way, the metacognitive raw data are elaborated to produce a more refined set of data that serve as input to the inference procedure (see Figure 2 (b)). In particular, the following computations take place. Given the mask:

$$a_{n,k}^{e} = \begin{cases} 1 & k_{n}^{e} \text{ON} \\ 0 & k_{n}^{e} \text{OFF} \end{cases}, \quad k = 1:K,$$

the following percentage per variable is calculated, denoting each peer’s intention to improve (see Table 1 and Figure 2):

$$PV_{n}^{e} = \frac{\sum_{k=1}^{K} a_{n,k}^{e} \cdot w_{k,n}}{\sum_{k=1}^{K} w_{k,n}}, \quad \lambda = 1:5.$$

The values of the $PV_{n}^{e}$ variables indicate the individual contribution to pair work. Thus, all the C/R-FIS variables share a universe of discourse of [0-100%].

**Preliminary results and discussion**

A prototype of the C/R-FIS model, using Matlab 6.5 (Mathworks, Inc.) and MS FrontPage 2000 (Microsoft), was developed and was integrated into Lin2k, to provide the enhanced Lin2k, i.e., eLin2k. In all FISs, the mfs employed were of a triangular shape and the connectives AND, OR, and ELSE were modeled by the operators prod, max, and max, respectively. Furthermore, the Mamdani min implication operator was used and the mom (mean of maxima) defuzzification method was selected, to give values at the edges of the universe of discourse (Tsoukalas, 1997).
In Figure 3, the mfs that were employed in the $IV_{s,z}^{+}$ ('argumentation') FIS are given. The universe of discourse of the input variables ‘work’, ‘initiative’, and ‘questions’ is described by the three fuzzy values ‘low’, ‘satisfactory’, and ‘high’ (see Figures 3(a)-(c)). In addition, the universe of discourse of the output variable ‘argumentation’ is described by the four fuzzy values ‘low’, ‘good’, ‘very good’, and ‘excellent’ (see Figure 3(d)). The structure and position of these triangular mfs, within the universe of discourse of the values of each variable, reflect a very close attitude of the evaluator’s model to a conventional evaluating system (i.e., use of mark 5 as a threshold for a low performance and 8 for distinguishing between satisfactory and high performance). In addition, by means of the triangular shaped mfs, this approach becomes more robust to noise and allows for flexibility of the function of the thresholds. These benefits result from the fuzzy logic-based structure, and are even more highlighted by the mfs of the output variable i.e., the argumentation. In terms of more mfs, the universe of this variable is more analytically described. This approach provides a more sensitive estimation of the argumentation value, which then serves as a more refined input to the next level of inference.

The above mfs were integrated within nine IF/THEN rules, which constitute the rule-base of the $IV_{s,z}^{+}$ FIS. In particular, this rule-base describes the model for the evaluation of the argumentation during the collaboration at each step. Figure 4 depicts an instance of the function of the rule-base, where the values of the input variables (see Equation (1)) $IV_{s,z}^{+} = 20$, $PV_{s,z}^{+} = 50$, $PV'_{s,z}^{+} = 15$ were introduced to it. As it is evident from Figure 4, with the specific input values, the first rule was activated (fired). The relevant linguistic expression of this rule is:

‘IF work is low OR initiative is low OR questions is low THEN argumentation is low’.

Thus, at the LHS of the rule only the mfs of ‘work’ and ‘questions’ were used for the fuzzification procedure. Due to the $\max$ operator (equivalent to the connective OR) the maximum of the fuzzy numbers at the LHS was combined with the RHS of the rule. More specifically, it performed clipping to the mf that describes the ‘low’ performance of ‘argumentation’. The remainder area was finally aggregated as the fuzzy output of the rule-base. By means of the $\text{mom}$ method, it was defuzzified to the crisp value $IV_{s,z}^{+} = 20$.

An experimental use of the eLin2k was conducted, namely EXP2, for the realization of the efficiency of the C/R-FIS model. The experimental set up was similar to the EXP1 that was conducted with Link and reported in (Hadjileontiadou et al., 2003), i.e., 64 undergraduate, randomly selected, engineering students (different than the EXP1 ones), worked, through a six-step ($s = 6$) collaboration, on a case study from the environmental engineering field (Hadjileontiadou et al., 2003). This setting materialized a promising use of the Web for distance collaboration on environmental issues, by bringing together experience upon local problems.
In order to evaluate the efficiency of the C/R-FIS, the convergence to the BCA zone derived in the current experiment, EXP2, was compared to the one seen in the EXP1 (Hadjileontiadou et al., 2003). The latter served as the control situation for the evaluation of the experimental findings of the EXP2, as depicted in Figure 5.

From Figure 5 it is evident that the eLin2k resulted in better convergence (smaller deviation around the 50% line) to the BCA zone in an earlier (step 3) than the Lin2k. Since the students in the performed EXPs were different, we used the *t*-test for independent samples for the statistical analysis of the *C*·· and e*C*·· values (Kinnear et al., 2000). The results from this analysis verified that there is statistically significant difference (*p* < 0.05) after the third step. This fact revealed the efficiency of the eLin2k supporting mechanism through the C/R-FIS integration. In particular, the automated character of the C/R-FIS function, by allowing the use of a large number of variables, increased the accuracy and validity of the evaluative inferences, thus the quality of the provided support. Moreover, the dynamic character of the C/R-FIS model, allowed for an updated evaluation inference upon the collaborative activity at the end of each step. In this way, it inherited a formative character to the provided feedback, which resulted in an improving performance towards the last steps.
C/R-FIS transferability

The flexible structure of the C/R-FIS allows its adaptability to the evaluator’s needs by means of varying for example, the mfs, the weights, or the variables according to the evaluation rules adopted each time. Under this perspective, the C/R-FIS can contribute to better collaborative performance in various scientific fields e.g., medicine, environmental engineering, law, music education, exhibiting high transferability to collaborative learning in many contexts.

Regarding the music education, for instance, the C/R-FIS model could be used during a music composition task to encourage the peers towards more productive collaboration, as it is reflected through their collaborative interactions (Nikolaidou, 2002). Under this perspective, a case study was carried out in a public primary school in Thessaloniki, Greece, to explore in depth which kind of collaborative talk can be produced by the pupils when they work in pairs doing composition with and without using Information Communication Technology (ICT), and to set a test-bed for a potential implementation of the C/R-FIS model. The experiment started by prompting pupils to compose a short melody for setting some verses that they had previously written, formed in simple language and with a descriptive character. There were two different samples of composition. The first one was a short melody without employing any ICT-based environment, while the second one was based on the music notation software namely, “Finale 2003” (CodaMusic Technology, Inc.), a powerful integrated program for music transcription, notation, playback, and publishing (Finale, 2003). Interacting with the simpler parts of this software pupils had the opportunity to produce their own compositions more quickly and easily than the traditional ‘pen and paper’ method, alongside listening and modifying the sample of their musical piece. Moreover, the software allowed them to play and print the final score. The task duration per pair was approximately 12 –15 minutes. Since the experiment was conducted on children of 11 years old, a free-dialogue model was adopted and their collaborative interactions and musical outcome were videotaped (separate cameras for students’ faces and computer screen) and transcribed, accordingly. Figure 6 depicts a sample of the acquired information.

Figure 6: Collaborative attitude and dialogue during a music composition task.

Furthermore, Tables 2 and 3 present dialogue excerpts from pairs collaborating under the same music education case study on a music composition task without and with ICT, respectively.

Table 2: Excerpt from the dialogue developed without ICT-based means.

<table>
<thead>
<tr>
<th>Student</th>
<th>Dialogue</th>
<th>Collaborative contribution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boy A</td>
<td>Shall we put a triple?</td>
<td>Question seeking for proposal</td>
</tr>
<tr>
<td>Boy B</td>
<td>Do you want semi-quavers?</td>
<td>Question seeking for proposal</td>
</tr>
<tr>
<td>Boy A</td>
<td>No, wait! Well, now put an E note</td>
<td>Proposal</td>
</tr>
<tr>
<td>Boy B</td>
<td>D,D,E,E,D,D,C,C (notes)</td>
<td>Proposal</td>
</tr>
<tr>
<td>Boy A</td>
<td>Why??…?</td>
<td>Question seeking for explanation</td>
</tr>
<tr>
<td>Boy B</td>
<td>It seems quite low, doesn’t it?</td>
<td>Comment</td>
</tr>
<tr>
<td>Boy A</td>
<td>Let’s put some higher notes</td>
<td>Proposal</td>
</tr>
<tr>
<td>Boy B</td>
<td>Why do you want the higher notes?</td>
<td>Question seeking for explanation</td>
</tr>
<tr>
<td>Boy A</td>
<td>It is not very good? I don’t know</td>
<td>Question seeking for critique, comment</td>
</tr>
</tbody>
</table>
Table 3: Excerpt from the computer mediated dialogue using ‘Finale 2003’.

<table>
<thead>
<tr>
<th>Student</th>
<th>Dialogue</th>
<th>Collaborative contribution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Girl</td>
<td>If we put F, E, C notes?</td>
<td>Proposal</td>
</tr>
<tr>
<td>Boy</td>
<td>F, E, C notes?</td>
<td>Question for self-thinking</td>
</tr>
<tr>
<td>Girl</td>
<td>No, F, E notes …</td>
<td>Contra proposal</td>
</tr>
<tr>
<td>Boy</td>
<td>…D note</td>
<td>Elaboration of the previous proposal</td>
</tr>
<tr>
<td>Girl</td>
<td>C, F, E, D, C notes… (thinking)</td>
<td>Elaboration</td>
</tr>
<tr>
<td>Boy</td>
<td>We can write F, E and a C minim, or we can write a crotchet</td>
<td>Proposal</td>
</tr>
<tr>
<td>Girl</td>
<td>F, E, G notes</td>
<td>Contra proposal</td>
</tr>
<tr>
<td>Boy</td>
<td>F, E, G notes. Ok. But we have to write the minim. Do you Agree?</td>
<td>Agreement, question seeking for confirmation</td>
</tr>
<tr>
<td>Girl</td>
<td>Yes</td>
<td>Agreement</td>
</tr>
<tr>
<td>Boy</td>
<td>Fine. F, E, G notes (Girl writes the notes) Fine.</td>
<td>Action</td>
</tr>
</tbody>
</table>

From the dialogue excerpts presented in Tables 2 and 3, it can be argued that there is a noticeable difference among the contributions, as they are categorized in Table 1, that are developed when pupils work collaboratively on a composition task with the traditional way and within an ICT-based environment. When reflecting on findings of the discourse analysis of the collaborative music composition work based on a traditional and a non-computer based environment, respectively, results have shown the effectiveness of ICT in children’s music knowledge through their talk in primary school. In particular, the pupils who compose in a traditional way (Table 2) had more difficulty in manipulating their ideas about the composition. Although they made a significant number of proposals based on their creative ideas the other kinds of collaborative contributions (see Table 1) were clearly limited. On the other hand, children composing within an ICT-based environment (Table 3) appear to introduce more creative ideas and bring their suggestions into the group. Moreover, pupils’ contributions relate to one another and there is evidence that they are talking on the same point. Their dialogue includes proposals and contra proposals and they elaborate their ideas. Finally, they agree to a point and their sequence ends up with an action. This increases the information between them, enhancing their decision-making and, therefore, improves their quality of thought in composition during the collaborative learning process. In the traditional learning process, children can develop their own understanding but they do not explore the whole construction of knowledge taking advantages from the benefits of a joint solution. This phenomenon can be explained due to the absence of a ‘vivid’ musical environment where pupils can manipulate their composition, and listen to it, as they can in the ICT-based one.

![Image 1](image1.png)

**Figure 7**: Adaptation of eLin2k to the concept of ‘Music Village’.

Although this music education case study differs from the environmental one used in the evaluation of the C/R-FIS model (Hadjileontiadou et al., 2003), it provides a field of potential use of the C/R-FIS model, enhancing its transferability. This is due to the similarity seen between the collaborative information the computer-mediated music education provides (Table 3) and the collaborative data the C/R-FIS model uses (Table 1). From this perspective, a modified eLin2k collaborative environment could be designed, adapted to the pupils’ capabilities, learning capacity, and needs, in order to facilitate their collaboration and to provide appropriate feedback for
convergence of their collaboration activity towards the BCA zone. An example of such modified eLin2k collaborative environment is shown in Figures 7 and 8, which depict the concept of ‘Music Village’ and the setting for the realization of the collaborative composition task respectively.

Figure 8: (a) A general description of the composition task. (b) A snapshot from the adapted eLin2k interface for step one (s = 1).
In particular, in Figure 8(a), a general description of the composition task is given. Then, it is divided into 10 steps \( s = 10 \) with different task instructions to and expectations from the pupils at each step, all fitted within a game context. Figure 8(b) presents the task description and the expected deliveries at the end of the first step, the text editor, common and individual workspaces, ‘Finale 2003’ music editor, and submission choices for the collaborative contributions and task material. To this end, the convergence to the BCA zone could resemble the evolution of a game through time, consciously encouraging the pupils (through the feedback provided by the C/R-FIS model) to successfully follow the game rules (hence to increase their game score by ameliorating their collaborative attitude), yet unconsciously leading them to equal collaboration.

This is just a scenario of the potential use of the C/R-FIS model in music education; however, further experimental uses of C/R-FIS will allow the justification of the promising results reported in the present study. Ongoing research efforts are towards that direction.

Conclusions

In this paper, the C/R-FIS model is proposed; it materializes a process-oriented approach to the analysis of online written collaborative activity, by focusing on the interactions that take place. Under this perspective it introduces a level of abstraction for the elaboration of empirical data by means of a set of variables resulting in the production of refined information. In particular, it constitutes a fuzzy logic-based expert system that produces evaluative inferences upon the peers’ collaborative and metacognitive interactions. The C/R-FIS holds a modular structure that allows successive interconnected levels of inferences to take place upon a large number of variables. The benefits from this structure are twofold. Firstly, it lends more reliability to the produced inference, due to the large number of the variables employed, as compared to the human ability to perform a similar task. Secondly, it allows the use of different variables from the ones proposed here, according to the pedagogical scenario under consideration. Under this perspective, along with the flexibility in its parameters adjustment, it may be implemented in modeling of complex evaluation structures, facilitating the interested evaluator to successfully evaluate the quality of the peers’ collaborative activity and inference upon their support. Moreover, the automated function of the proposed model, lends a formative role to the above support, increasing the possibility to result in enhanced learning of the ‘proper’ collaborative performance.

The integration of the C/R-FIS model within a web-based collaborative tool, namely Lin2k, resulted in the extended eLin2k, with automated the current manual evaluative procedures, which were carried out in Lin2k upon the peers’ collaborative and metacognitive interactions. Experimental results derived from the eLin2k tool when compared to the Lin2k ones prove the efficiency of the proposed model to successfully guide the peers towards a more balanced collaboration. Moreover, C/R-FIS low computational cost makes it into a promising technological tool that may contribute to the enhancement of peers’ collaborative skills within distant collaboration situations. Finally, its transferability to collaborative learning in many contexts, as it was presented through a music education case study, makes it flexible and attractive for many modular collaborative learning environments, provided that some appropriate integration procedures take place. These procedures pose challenges for further research concerning their analysis in relation to the age of the peers’ (e.g., redesigning of the communication model and adjustment of the variables employed), or to the size of the group (e.g., allow more than two peers to collaborate). Current research is focused on repetition of eLin2k experimental uses in higher education with different tasks of collaboration, aiming at the verification of the effectiveness of the proposed model and the validation of its impact on the quality of the collaboration outcome.

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Supporting a Learner Community with Software Agents

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Abstract
This paper describes a multi-agent approach that aims at supporting learners involved in a collective activity. We consider pedagogical situations where students have to explicitly define the articulation of their collective work and then achieve the different tasks they have defined. Our objective is to support these students by taking some of these tasks in charge whilst making them work out such organisation features. For this purpose, we propose to consider that the group of students forms a multi-agent system and to introduce software agents that can achieve some of the tasks within this group. This conducts students to tackle the problem in terms of human and software agent coordination. We present how this approach can be conceptualized and modelled using Engeström’s triangle, how task delegation can be used as a means to enable students to define the software agents’ behaviour and the multi-agent implementation we propose.

Keywords
Collective learning, Activity theory, Multi-Agent System

Introduction
The general context of our work is the study of collective activities in a learning context (CALC; Betbeder & Tchounikine, 2002). The term “activity” will be used in this paper to denote both what students are asked to do, i.e. the “pedagogical activity” and in the broader sense of “students’ activity”. Additional precision will be made when the context is not clear enough to distinguish these meanings in learning contexts. More specifically, we tend to support distance students in defining the articulation of their collective work in a way that leads them to have a reflective analysis of their activity. For this purpose, we have developed Symba (Betbeder & Tchounikine, 2003), a Web-based environment that helps students to organize themselves. However, analyzing students’ interactions about their organization and activities highlighted that a large part of these interactions are in fact not interesting, neither from the point of view of the learning objectives nor from the social point of view of making students aware of each other. It therefore appears interesting to support students by taking this part of the work in charge.

In this paper we present an approach based on introducing software agents into the group of students with the objective of (1) supporting students by taking some uninteresting parts of the work in charge whilst (2) enhancing the pedagogical objective (i.e., that students should work out organisational features) by proposing a protocol focusing on organisational features.

Section 2 presents the general context and objectives of this work and the multi-agent approach we propose, section 3 describes how we use Engeström’s triangle (from the activity theory) to conceptualize the way we integrate the agents in the community, section 4 discusses how we have put this approach into practice and section 5 talks about the multi agent implementation we propose.

Context, objectives and general approach
The Symba framework
The Symba framework (Betbeder & Tchounikine, 2003) is a Web-based environment for CALCs designed to emphasize and render explicit organisation features in order that students should have a reflective activity on their organisation.

A typical example of the type of collective activities we consider is that of a group that has to (1) identify how conceptual maps can be used to describe a curriculum, (2) propose different individual points of view of their curriculum and then (3) construct collectively, from their individual productions, a conceptual map describing...
their curriculum. Such activities are designed with a double pedagogical objective, making students address some feature of the curriculum domain (conceptual maps) and making students practice collective work and, in particular, work out how they have to organise themselves: decompose the work to be done into different individual and collective tasks, organise these tasks (beginning and ending dates, input, output, etc.), define what tools should be used to perform each of them: file transfer tool, mail, chat, Forum.

Symba presents two environments. The organisation environment enables students to define the set of tasks to be realized, delegate these tasks to an individual or a subgroup (eventually the entire group itself) and specify the tools and resources that are required to achieve these tasks. The activity environment then provides the tools and resources that have been asked for at the organization level.

**Requirement for some additional support**

In Betbeder, Taurisson & Tchounikine (2003) we presented three different levels of support that could be proposed to a CALC community with the different kinds of tools that could provide these particular levels of support:

- The “conceptual support” provided by conceptual tools (models and methodology). For instance, in Symba, the proposed conceptual tool is the task notion.
- The “task achieving support” provided by general purpose tools. For instance, Symba proposes different general tools such as a chat, a mail or a file exchange tool, general tools that support users in achieving some tasks.
- The “task handling support” provided by tools that are able to take the achievement of a given complex task in charge e.g., organize a vote.

In this paper, we consider this “task handling support”. The importance of proposing this type of support was raised by an analysis of the different chat, mail and forum discussions from different experiments through a communication - acts grid (Betbeder & Tchounikine, 2002). This analysis highlights that although a great amount of communication-acts are related to organisational features (i.e., concern our core pedagogical objective), a large part of these interactions are in fact not interesting, neither from the point of view of the learning objective nor from the social point of view of making students aware of each other. A typical example is the finding of a date for a synchronous meeting, which requires centralizing each participant’s availability to propose a date that seems to be suitable. For such a task, one of the students must achieve a boring and time consuming job (multiple cycles of sending mails and compiling answers) for the community benefit. Such tasks, which have been analyzed in the role conflict theory (Watt, 1993) as potentially causing breakdowns of the community, should be avoided.

**The community as a multi agent system**

In order to avoid students spending time on features that are pedagogically counterproductive frameworks usually propose tools that deal with these features. However, the fact that the CALC environment should provide task - handling support to avoid community breakdowns caused by role conflict must not come into conflict with our pedagogical objective: get students to have a reflection on their organization. Therefore, articulation tasks such as the finding of a date must not be hidden by the CALC or compiled into a black box.

The approach we propose is to provide task- handling support by integrating software agents that can be delegated these specific tasks, into the community. This way, tasks potentially causing role conflict are handled by the environment whilst remaining explicit in the organization. Within this approach, students do not use tools, they define a task to be handled by a software agent, in a similar way that they define some other tasks to be handled by human agents. The emphasis thus remains on organisational features (defining and delegating tasks), i.e., the point we want them to work out. A tool is viewed by its user as a manner of doing something. The relation between a tool and its user is individual: what can I do with it, how can I use it? Very differently, the relation between actors is collective: what can I do with him, how can we work together?

Within our approach, the setting of a collective activity is therefore conceptualized as a multi agent system where human agents are collaborating to achieve a common goal (Dillenbourg, Baker, Blaye & O’Malley, 1996). Coherently with the distributed cognition theory (Hollan, Hutchins & Kirsh, 2000), a group of students involved
in a CALC must not be analyzed as an addition of individual agents: the group must be considered as a cognitive system.

**Coordination aspects**

Differently from software agent communities, the articulation of the collective work of such a human community cannot / must not be modelled and automated a priori (Suchman, 1987; Dillenbourg, Baker, Blaye & O’Malley, 1996). Moreover, we do not attempt to automate coordination like multi-agent architectures do, we want the students to work it out. The agents we intend to introduce in the community are therefore limited to articulation tasks, e.g. finding a date, organizing a vote or dealing with file exchanges. Coordination remains a human-concerned feature: the work to be achieved is organized by a community composed of the students and it is achieved by an extended community composed of the students (considered as human agents) and the software agents. However, although the software agents are not in charge of the control, their impact on the overall organisation must be studied carefully.

Guidelines for specifying and analyzing the agents’ role can be found in Schmidt and Simone’s work on coordination mechanisms, that they define as “a construct consisting of a coordinative protocol on the one hand and on the other hand an artefact in which the protocol is objectified” (Schmidt & Simone, 1996). Every collective activity is associated to a coordination protocol, although it can remain implicit. Schmidt and Simone’s work highlights the interest of reifying some coordination aspects in an artefact in order to make them accessible and non-ambiguous to all members of the community. It points out different important features such as the fact that some articulation tasks of the protocol should be automated so as to relieve actors from always having to pay attention to the respect of the protocol, that the protocol should be flexible enough in order to allow local changes without requiring the whole community to redefine it or that the protocol cannot be defined entirely before the activity takes place, it should be possible to start with an imprecise protocol that will be defined more precisely in action.

Within our approach, the artefact reifying the protocol is the Symba organization environment, where every task can be browsed through by all the members of the community. The software agents, although limited to articulation tasks, manage however a certain part of the protocol, relieving human agents from having to permanently watch that, for example, the time schedule is respected by all. Following Schmidt and Simone’s principles, the software agents must be flexible enough so that students experiencing temporary problems should not be rejected from the activity. As an example, this means that the agent in charge of collecting documents must be tolerant for latecomers and accept (to a certain extent) documents provided after the deadlines.

From a general point of view, integrating software agents to a community imposes a certain level of rigidity as software agents cannot implicitly understand the community organization as humans do: integrating software agents requires an explicit definition of the community work articulation. This could be seen as a negative point if our objective were limited to facilitating the collective work. However, as our principal goal is to encourage students to work out organization features, such explicitness in fact participates positively to the clarification of the organization.

**Conceptualisation**

**Theoretical background: the activity theory**

Software agents cannot be introduced in a human community (in particular a students’ community) without analyzing the impact from the humans’ point of view. We must understand how learners can perceive the agents and their impact on the work to be achieved in order to study the agents’ characteristics and their status in the group / in the framework.

The activity theory is a general framework for studying different forms of human activity as development processes (Kuutti, 1996). Issued from the soviet cultural historical research tradition, it has recently come back to the front of the scene as a theory that provides conceptual tools to describe and analyze an activity as a social development process. Within our context, the activity theory is particularly interesting in that it postulates that an activity has to be analyzed both as an individual process and a social process.
Within this general context, Engeström (1987) proposed a model (Figure 1) emphasizing that an activity is oriented by an object shared by its community. What motivates the existence of an activity is the willingness of its subject (which can be a collective subject, eventually the entire community) to transform this object into a product. What makes this model attractive for analyzing an activity is that it is a good structure to isolate elements of different natures constituting the context of an activity and to highlight mediation relationships between elements. As an example, the subject is related to the community by a set of rules, the relationship between the subject and the object is mediated by a set of tools (tool is meant here at a conceptual level: it can be a document or, within our context, a chat.), the community is related to the object in the context of a given division of labour, etc. (Figure 2). As highlighted by Lewis (2000), focusing on triads of the Engeström model is a way to understand the impact of one element of the activity on another by the mediation of a third. For our analysis of the integration of software agents to the students’ community, the triads from the down part of the Engeström triangle are particularly interesting as they focus on the collective side of the activity.

Within our research we state as a working hypothesis that, although the activity theory is a descriptive framework for analysis, its notions can be used in a more prescriptive way to design computer-based
frameworks. Following this hypothesis, we use the Engeström triangle as a conceptual framework to both (1) analyze the integration of software agents in a CALC and (2) define the protocol followed by students to describe their (and the agents’) activity, task modelling and task delegation.

**Studying the impact of the integration of software agents into a CALC community**

In order to understand the possible impacts of the software agents on the learners’ activity we focus on the down part of the Engeström triads, that are oriented at the collective side of the activity. For example, we analyze the impact of a software agent (considered as a subject) on the community in terms of imposition of rules or modification of the division of labour. From these triads we can anticipate features such as described below:

- Defining an agent’s task should make rules and division of labour explicit. Defining a task to be handled by a software agent requires specifying what rules it will have to follow and how its work has to be articulated with others. We can see here that the integration of agents will have an impact on the subject-community-rules triad and on the subject-community-division of labour triad, as rules and division of labour will have to be explicit in order to enable their understanding by the software agents.

- Defining an agent’s task should help learners to clarify their shared object. Focusing on the subject-object-community triad, we can anticipate that the expression of rules and division of labour will require clarifying the object.

The agent activity itself should encourage that changes to the rules and division of labour are explicit. Software agents do only what learners tell them to do. This has once again an influence on the subject-community-rules and subject-community-division of labour triads in that changes to rules or division of labour need to be explicit. This will lead learners to have a reflection on the organization all along the achievement of the activity.

From a general point of view, although in our case the control remains the students’ responsibility, integrating software agents to the community imposes a certain level of rigidity. This rigidity is caused by the fact that software agents cannot understand implicitly a community organization as a human would: integrating software agents requires an explicit definition of the community work articulation. This could be seen as a negative point if our objective were just to facilitate the collective work. However, as our principal goal is to encourage students to work out organization, such explicitness participates positively, in fact, in the clarification of the organisation.

**Task modelling and task delegation**

Students define through Symba, in an integrated way, both the tasks they will achieve themselves and the ones that will be achieved by software agents. As stated previously, the way these tasks are defined must incite students to focus on organization features. For this purpose, we have modelled the task notion in a way that denotes Engeström’s triangle notions.

For the tasks they achieve themselves, the students have to define the objective (in natural language), the nature (individual or collective), the subject (an individual, a sub-group, or all the group), the beginning and ending dates (rules), the tools (the general-purpose tools that will be accessible at the activity-level to achieve this task, e.g. a Chat or browser), and the resources and productions (file names). Tasks delegated to software agents are described similarly with some additional slots to be filled according to the task specificities. As an example, figure 3 presents a date search task delegated to Nicolas; the additional slots are the meeting duration, the meeting participants and the meeting enclosing dates. The system dynamically generates a natural language description of the task in order to avoid possible misunderstandings of the interface.

This approach allows students to specify the agent’s behaviour through a task delegation semantic. This semantic (inspired from Engeström’s notions) is conceptually simple for the students and makes them work out the competences that correspond to our pedagogical objective: defining the software agents’ tasks requires having a clear idea of the software agent’s role and how it will be articulated with the other agents’ tasks.
More generally, the need for precision required for agents has a border effect on the organization activity in general as it leads students to have the same precision when they come to defining their own tasks.

It can be noticed that delegating tasks to software agents is a way for human agents to tailor their environment: when defining the software agents, the students modify the functionalities of the “system”, i.e., how the Symba environment can support their activity (this goes further than simply modifying some interface features such as “preferences”). This is an innovative approach to the notion of tailorable systems as defined by Morsh (Morsh, 1997), i.e., integrating a way to tailor the system as one of its functionalities. When providing users with the possibility of customizing their environment at a functional level, a classical problem is that of the programming language in which these users can express their desires. Programming requires the respect of a formal grammar, and programming language grammars requires skills that cannot be expected from students; this is one of the principal causes of un-usability of tailorable systems (Morsh, 1997). The task delegation semantic we propose is an approach that moves the problem from programming through a computer-science semantic to expressing the organisation of an activity (Betbeder, Taurisson & Tchounikine, 2003).

**Putting Into Practice**

**Definition of the software agents’ roles**

The approach presented in this paper has been experimented in the context of a collective activity that takes place in the fifth university year of a computer science curriculum. The activity consists in collective and individual phases on the theme of conceptual maps, engaging students in producing individual and collective documents and exchanging them, planning synchronous meetings or voting for a decision to be taken (asynchronously and synchronously).

In order to define what software agents should be defined we have used the “role conflict” theory defined by Watt (1993), that provides a scientific basis for the empirical conclusions we have drawn from our analysis of previous experiments (Betbeder & Tchounikine, 2002). As explained before, Watt stated that, in a groupware
environment, an actor may have to handle a task that requires additional work without any (or sufficient) direct benefit: the realization of a task will benefit to the community but the member who has to handle it perceives his role as being less attractive than the others. This situation can lead to a community’s breakdown as the one whose role seemed less attractive will not engage himself in the task, even though this may cause the common goal not to be achieved.

When concerning a group of humans, potential role conflicts must be avoided by getting different roles to be equivalent. However, in a hybrid groupware mixing human and software agents such as Symba, there is a benefit in that software agents handle tasks that can lead to a role conflict: this will make the use of the software agents more attractive for humans and it will reduce the risk of a community breakdown.

The software agents that have been implemented and introduced in the 2002 experiment have therefore been specified from the analysis of two previous experiments that corresponded to similar pedagogical activities (Betbeder & Tchounikine, 2002). This analysis allowed us to identify three tasks potentially causing role conflicts by requiring an unbalanced communication scheme, from which we specified and implemented three agents. Nicolas can find a date for a meeting when a group prepares a synchronous meeting. He sends a mail to each member of the community to ask them their availabilities, synthesizes the answers and proposes a date (eventually iteratively). Chick can organise a vote when the group must decide something collectively either as a top-level task (i.e., one of the tasks explicitly scheduled by the students) realized asynchronously by Mail or “live” during a synchronous meeting and achieved by Chat. Colin can handle document flow of the data produced or to be used by the group. He asks the members of the group to supply their documents and distributes them across the community (making a synthesis of individual works or getting documents to be downloaded from a Web site).

Human / software agents’ communication

Human / software agents’ communication must not impose features that are pedagogically counterproductive or that can discourage students from using the agents.

![Figure 4: Chick interacts in a chat (Snapshot from the 2002 experiment: the agent Chick interacts with the student Jack; the text is translated from French)](image)

In our context (distant students supported by a Web-based environment), communication tools (i.e., chats, electronic messages and forums) are the principal vector for the perception of the community and its members. Therefore, similar to the students, the software agents have been implemented with capabilities to communicate
by mail (when asynchronous) and chat (for synchronous, cf. figure 4). For instance, Chick (the vote organiser) uses Mail when used asynchronously and Chat when used synchronously. Student / software agent and student / student communication are therefore homogeneous.

First results of the study

We have implemented the three agents described to study their integration in the community in an ecological experiment: groups of students from the fifth year of a computer science university curriculum engaged in an activity through the Symba framework.

The first results of the experiment highlight that the students are not bewildered by the introduction of these software agents and they in fact use them. A certain number of difficulties were raised from surface misunderstanding of the interface, but defining agents’ tasks through the “activity triangle” grammar seems easy for the students.

However, the experiment highlighted that students require the agents to be glass boxes much more than human agents would. As an example, although Nicolas’s protocol to find a date is similar to the one observed from students in the preceding experiments, it seems that students feel a loss of control after they have answered Nicolas’s mail: they require an extended awareness of the software agents’ behaviour (it seems natural to send a mail to another student and wait for his answer, but an agent should answer immediately or, at least, explain what he is doing).

A scalable implementation for a MAS mixing human and software agents

In most multi-agent systems (MAS) where human and software agents are interacting, software agents are lower level of granularity agents than human. The particularity of our approach is that human and software agents are at the same level of granularity: software agents handle tasks that are similar to the human’s tasks and interact at the task level in a human environment with human agents as peer.

As we have modelled the community as a multi-agent system mixing human and software agents, we want to keep a structural correspondence between the model and the implementation. Therefore, we have developed a multi-agent system in which both human and software agents are represented. Learners (human agents) are represented in the MAS through “proxy agents”. Proxy agents are a bridge between the outside world and the multi-agent system (see figure 5). For example, when a learner sends a message to a software agent through an email tool, the email is intercepted by the proxy agent representing this learner in the MAS. The proxy agent then sends a message to the software agent using the multi-agent framework messaging primitives. In the same way, when a software agent needs to send a message to a learner, it sends a message to the proxy agent in the MAS, and the proxy agent then transcribes this message in the “real world” messaging tool sending it to the learner. In other words, the MAS models the overall activity of the human and software agents.

Figure 5: Proxying messages from and to the "real world"

From a multi-agent perspective, our approach is coherent with the “agentification of services” principle developed by Ferber (Aalaadin model, Ferber & Gutknecht, 1998). Within this model, the mechanisms that are
connected with the multi-agent principles such as the “distribution mechanism” (distributing a multi-agent over different computers) is modelled as a specific agent intercepting messages to forward them to another site. This approach is very powerful as the implementation features (in this case, foreign messaging) is the agent’s responsibility, the system only has to make sure that an agent exists to provide the service.

We have therefore used the Madkit framework (the Multi Agent Development Kit developed by Ferber on the basis of the Aalaadin model) to implement the framework services. This “agentification of services” approach allows us to conceptualize a multi-agent system in a recursive way: an agent can be conceptualized itself as a multi-agent system of lower level agents. We also use this principle to implement general services for the agent’s community such as a timer agent that can be asked to send a message at a particular time.

From an implementation point of view (cf. figure 6) an agent consists of a multi-agent system composed of: 1) a façade agent, 2) a task manager agent, 3) a rule scheduler agent and 4) a dialogue agent.

![Diagram of a Multi-Agent System](image)

**Figure 6:** The software agent : a Multi-Agent System composed of lower level agents

To illustrate the powerfulness of this principle we can focus on the dialogue agent. Currently, the dialogue agent is implemented using a simple state automaton. The façade agent receives a message from some other agent, it then forwards it to the dialogue agent that processes it (using the automaton?) and sends the result back to the façade agent that deals with it (sending a response to the original message sender or acting on the environment). We are currently working on replacing the actual state automaton dialogue agent by a more sophisticated dialogue agent. For the façade agent, nothing would be changed, it would still delegate the processing of the message and react in function of the processing result.

**Conclusions**

We have proposed an innovative approach that consists in introducing software agents within a group of students in a manner that supports students by taking in some uninteresting parts of the work in charge whilst enhancing the pedagogical objective of making students work out organisational features. We have presented how this can be put into practice through a task delegation principle, a possible approach of the modelling of these tasks inspired from the Engeström triangle and an implementation based on the “agentification of services” approach.

The first experiments demonstrate that this approach is realistic and influences the overall students’ activity in a way that corresponds to our pedagogical objectives.

Different features pointed out by the experiments are under analysis, in particular enhancing the perception by the students of the software agents’ activity and combining different agents’ activity, e.g.: collecting documents...
(Colin), placing them on a web site (Colin), organising a vote to know if these documents are ok (Chick) or re-collecting documents if not.

References


Virtual Learning and Higher Education

Edited by David Seth Preston

(At the Interface / Probing the Boundaries 8)

Textbook (minimum order 10 copies):

It is clear that the Internet and other global information infrastructures provide a major challenge to Higher Education. Questions such as the extent to which education should become ‘virtual’, the actual cost and value of such innovation and to what degree such education suits its stakeholders (e.g. students) are now discussed the world over. These issues formed the focus for a conference held at Mansfield College, Oxford in September 2002 and this book contains the most rounded and challenging papers from that event.

The book is divided into three main parts which consist of the following themes within Higher Education: current practical and planned uses for Virtual Learning; the future ‘Virtual’ vision; and the large questions that remain unanswered behind ‘Virtual Education’.

The contributors range from the nerdy end of experimenters of futuristic innovative technologies via the practitioner middle of well-known organizers of existing virtual systems to the other extreme of the critical engagement of philosophers.

This stimulating and important book is aimed at researchers of topics such as technology-driven Education, Philosophy, Innovation and Cultural Studies. It is also meant to appeal to anyone with interest in the impact that the technological virtual will have upon Higher Education in future.

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Discovery and Use of Online Learning Resources: Case Study Findings

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Abstract  
Much recent research and funding have focused on building Internet-based repositories that contain collections of high-quality learning resources, often called ‘learning objects.’ Yet little is known about how non-specialist users, in particular teachers, find, access, and use digital learning resources. To address this gap, this article describes a case study of mathematics and science teachers’ practices and desires surrounding the discovery, selection, and use of digital library resources for instructional purposes. Findings suggest that the teacher participants used a broad range of search strategies in order to find resources that they deemed were age-appropriate, current, and accurate. They intended to include these resources with little modifications into planned instructional activities. The article concludes with a discussion of the implications of the findings for improving the design of educational digital library systems, including tools supporting resource reuse.

Keywords  
Case studies, Education, Human-computer interaction, Qualitative studies.

Introduction  
Much recent research and funding have focused on building Internet-based repositories that contain collections of high-quality learning resources, often called ‘learning objects’ (Wiley, 2001). Resources in such repositories are typically described using metadata, literally data about data (LTSC, 2000; Weibel, 1995). Much like a library card catalogue, metadata for learning resources usually contain basic information about the resource. For example, the Learning Technology Standards Committee (LTSC) Learning Objects Metadata Working Group (LTSC, 2000) defines an extensive scheme with over 80 elements to describe resources. These include, subject area, resource type, rights management, and author information. These metadata records are intended to support users (including teachers and students) in finding relevant resources.

The National Science Digital Library (NSDL) is an example of such an educational digital repository. The U.S. National Science Foundation sponsored NSDL provides access to a comprehensive collection of science, technology, engineering, and mathematics (STEM) education content and services to learners, educators, and academic policy-makers (Lagoze, 2002; Wattenberg, 1998; Zia, 2001). Similar national initiatives aimed at building large scale repositories of learning resources exist in other countries, including the Curriculum Online in the UK, the Canadian eduSource project, and the Australian Learning Federation.
To date, a primary focus of these initiatives has been on developing technical standards, metadata standards, and specifications for system interoperability. These efforts, it is claimed, will support the reuse of learning resources within a wide range of applications, and the seamless transition of content between learning management systems (ADL, 2001). In this way, the technical foundation will lead to faster development time, lower development costs, and produce better learning, education, and training (ISO, 2002; Sumner & Dawe, 2001).

However, missing from such initiatives is a deep characterization and understanding of learning environments, and how digital learning resources may fit into such contexts. Developing this perspective requires adopting teacher and student perspectives, rather than simply focusing on technological concerns. Moreover, ignoring these perspectives risks hampering successful adoption of innovation (Moore, 1991), and the history of educational technology is replete with such omissions (Cuban, 1986). Unfortunately, the current learning object movement seems to have ignored the teacher and learner perspective. Few studies exist that document how non-specialist users, in particular teachers, find, access, and use digital learning resources (Friesen, 2003). In short, we lack understanding about the use and eventual effectiveness of educational digital learning repositories and resources in instructional settings.

To begin to address this gap, this article presents findings from a case study of mathematics and science teachers’ practices and desires surrounding the discovery, selection, and use of digital learning resource for instructional purposes. In selecting study participants, careful effort was taken to find teachers who, while experienced in the classroom, were not high-end technology users, as they are more representative of typical teachers. As described by Moore (1991) in discussing the processes of technology adoption, users can be viewed as comprising successive waves of adopters: Early Innovators, Early Adopters, Pragmatists (early majority), Pragmatists (late majority), and Traditionalists. The majority of technology users can be characterized as pragmatists. Many new technologies have encountered significant challenges in becoming adopted by the pragmatists. To do so requires establishing a niche market, providing an easy-to-use and enjoyable alternative, and demonstrating improved productivity in important areas (Moore, 1991). As such, our case study focused on the requirements of this class of users.

The purpose of the study was to identify teachers’ 1) motivations for using digital resources, 2) barriers to using digital resources, 3) search strategies and selection criteria when looking for digital resources, 4) adaptation of digital resources for their instruction, 5) use of digital resources in and outside of classroom instruction, and 6) desired functionalities in repositories and tools. In this way, the study focuses on understanding the teacher’s perspective regarding the prospects and uses of educational digital repositories of learning resources. Consistent with the case study methodology, the research approach was open-ended and exploratory (Johnson, 1997; Yin, 2003). Our intent was not to answer experimental hypotheses, but rather to begin to focus on developing research questions.

The context for this study was a formative evaluation of a digital library tool, called the Instructional Architect (Recker, Dorward, & Reinke, 2003). The Instructional Architect (IA) is a tool designed for use with educational digital libraries, by providing a container and authoring environment for resources found in such repositories. As will be described, study participants were asked to engage in a number of activities involving the use of digital resources for instructional purposes. Specifically, they were asked to use Internet search engines, educational digital libraries, and the IA to locate and use digital library learning resources in their instruction.

The next section of the article describes the context surrounding the study. Then, the study’s participants and methods are presented, followed by a description of the findings. The article concludes with a discussion of the implications of the findings for improving the design of digital repositories of learning resources, including tools supporting resource reuse.

**The Context for the Study**

The Instructional Architect (IA) is an Internet-based service designed for use with educational digital libraries by providing a ‘container’ environment for resources found in a library (and is especially tailored for learning resources located with the National Science Digital Learning). In particular, it enables users (particularly teachers) to discover, select, sequence, annotate, and reuse learning resources stored in digital libraries into new instruction (e.g., lesson plans, study aids, homework). At the same time, it has the goal of fostering communities of teachers and learners who use the NSDL, by supporting resource sharing and recommendations. In this way, the IA is intended to increase the utility of learning resources for the classroom teacher. The IA portal is available at http://ia.usu.edu/.
Currently, the entry point to the IA offers several options. Returning users can log in to access (and edit) existing projects (instruction), or use the IA to create a new project (new instruction). New users can create an account, view an introductory tutorial, or begin accessing the system without logging in. The user can then use the Gather Resources Tool to find and collect learning resources, or the Author Tool to sequence and annotate these resources in order to create instruction, activities, lectures, lesson plans, study aids, or any other personalized collection.

Gather Resources Tool

The Gather Resources Tool supports searching across digital libraries for one or more learning resources. From a search screen, users enter their search terms, which are used to query participating digital libraries. Currently, queries are sent to a collection of metadata records from a variety of digital libraries including the National STEM Digital Library (nsdl.org), the SMETE Open Federation (www.smete.org), and the National Library of Virtual Manipulatives (matti.usu.edu). Search results are parsed and displayed by the IA to the user. Users can preview the candidate learning resources and then select (via a checkbox) resources they want to use in their own instruction (see Figure 1). They can also remove previously selected resources.

Author Tool

This tool provides several authoring functions that enable users to organize, sequence, and annotate selected learning resources into an instructional project. Specifically, the tool guides users through a series of steps in which they accomplish the following:

- **Add Title & Overview** – Create a project homepage including a title and brief introduction for the collection of resources.
- **Create & Organize** - Create, modify, delete and order individual webpages containing previously selected resources. Optional resource captions or descriptions can be added to scaffold learners’ interactions with individual resources (see Figure 2).
- **Preview Project** - See what the final project looks like.
- **Publish** – Receive a URL for the collection.
The outcome of interaction with the IA is a set of linked Web pages containing sequenced and annotated learning resources from participating digital libraries. These are saved on the server for future use, including as teacher presentations, learning activities, self-paced instruction, or in any other instructional situation. To facilitate use as broadly and as simply as possible, the IA is completely form-driven and compatible with any browser on any platform.

Design and development of the IA used both user-centered design (Norman & Draper, 1986) and developmental evaluation (Patton, 1994) approaches, in which each design cycle was followed by evaluation. In particular, the project design and development was informed by a needs assessment, expert review of the prototype interface, testing by members of the target audience, analysis of code changes by constituents, and a case study of master teacher use of software. An earlier article described how evaluation results were used to inform interface design (Dorward, Reinke, & Recker, 2002). The current article presents findings from analyzing the case study of teacher use.

**Participants and Methods**

Eight (five men and three women) experienced middle and high school science and mathematics teachers from the state of Utah were selected to participate in a study lasting ten weeks during 2002. Participant selection was based on candidates self-described level of electronic resource use in instruction, content background in the disciplines served by participating STEM digital libraries, and diversity of employment characteristics. In terms of information technology competence, we sought participants who were comfortable with, yet not high-end, information technology users.

The study consisted of the following phases:

- **Phase 1.** Informants attended a one-hour focus group, in which they completed a demographic survey and discussed their current use of Internet resources. The survey asked participants about their teaching area and experience, as well as to comment on their current use of Web-based learning resources in teaching. They then received a 2-hour training session introducing digital library concepts and tools, including the IA. As part of the training, they ran through two hypothetical instructional scenarios, one in mathematics education and the other in science education, in which they used the IA to create products.

- **Phase 2.** Four weeks. Informants were asked to use Internet resources in their teaching. They were asked to use their favorite search engine to locate resources. They completed coding sheets describing their activities.
In particular, for each activity, participants were asked to describe their instructional objectives, their search objectives, successes and barriers in their activity, and how their work was used in the classroom.

- Phase 3, four weeks. Informants were asked to use the IA to locate and use digital library resources. As in the previous phase, they completed coding sheets describing their activities.
- Phase 4. Researchers observed and interviewed Informants as they searched for and accessed learning resources for their students.
- Phase 5. Informants participated in a one-hour debriefing conference call.

Data Analysis Methodology

Data collected during the study included an initial survey of teacher demographics and attitudes toward the use of digital resources, coding and description of weekly instructional resource retrieval and use, pre- and post-study focus group interviews, and observations.

In order to describe how instructors search, adapt, and incorporate learning resources into classroom instruction, we compiled and analyzed a wealth of qualitative data. These data came from transcriptions of focus group interviews, from the coding sheets, and from observer comments. In the findings reported below, teacher quotes came from the focus group interviews in which participants were reflecting on their overall experience with using digital learning resources.

The three authors independently analyzed this qualitative information using QSR N6, a software coding and organization program (QSR, 2002), in order to identify recurrent themes. In most instances, there was consensus on resulting themes and associated textual information. In the few instances where interpretations varied, the team discussed the issues and reached agreement. As we will describe, many of the themes were validated by our prior research experience, while others emerged through discussion and debate.

Findings

The purpose of the study was to examine how teachers access, select, and use learning resources in the classroom. Findings addressed the following questions:
- What motivates teachers to use online resources?
- What barriers do teachers perceive to using digital resources?
- What search strategies and selection criteria do teachers use when looking for online resources?
- How do teachers adapt and use digital resources for their instruction?
- How do teachers use digital resources in and outside of classroom instruction?
- What functionalities do teachers want in tools that use digital learning resources?

Motivators for teacher use of digital resources

Overall, the teachers in the study felt that easy access to large numbers of high-quality learning resources increases their productivity by saving them time, improves their practice, and better meets the academic needs of their students.

With respect to how access to a breadth of high quality learning resources impacts productivity, teachers involved in the study always referred to time. The belief that searching the Internet saved time was reflected in the following comments:

"the access speed and breadth of content is much easier than [performing] manual searches of non-electronic resources.”

“this is my favorite thing about the Internet – you can get quick facts, tables and pictures to use at a moment’s notice.”

“Things are just so unlimited now. It is never like I need to go back to the library for more resources or I didn’t order enough books. It is all right there on the web, so that saves a lot of time.”
Study participants also believed that use of digital resources improves the quality of their teaching and their students’ learning. One teacher commented, “If I’m teaching out of a textbook what is that? I have to be on the Internet, I have to show them what is happening right now, shots from the Hubble, etc. That is just so valuable to the kids.” Another teacher was motivated to use digital resources because “students have more choice about what, when and how they learn - it’s the only way to generate interest and promote life-long learning.” The teachers also believed the process of accessing learning resources increased the level of technological literacy among themselves and their students. One teacher noted that, “These kids need to be learning the computer skills that will really get them ahead in life. … I know that the kids are getting a better education now.”

Barriers to teacher use of digital resources

Study participants also identified barriers to using digital resources. These barriers primarily related to the quality of the resources, and the abilities of teachers and students to access and use them.

Digital resources that were out-of-date, slow, unavailable, charged a fee, or contained information that was too “simple” or too “advanced” discouraged study participants: “it can be very time consuming finding relevant, timely, and grade-appropriate material – it requires a lot of ‘sifting’ through search engine hits as well as the sites and resources they offer.” One teacher noted frustration at “spending time on fruitless searches, which resulted in either lots of irrelevant resources or resources of less quality than that found in books.”

Search strategies and selection criteria

In general, teachers involved in this study used multiple strategies when searching for resources. Often they liked to start out broadly and review a number of resources, and then engage in more refined, specific searches. However, at other times they wanted to access resources on teacher-oriented Web sites that were already filtered or categorized, so that they could immediately start a refined search by grade level or topic. They preferred sites that were dependable, in particular well-known sites that provided collections of learning resources and links. One teacher stated, “I’ll find that the resources change so much from one year to the next. So what I try to do is stick with solid sites, like NASA, and that way I know that the site is only going to improve from year to year or month to month.”

When using Web search engines, the teachers generally preferred using Google, Yahoo, and WebCrawler, as well as education-specific search engines. One teacher tended to focus on “the first couple of pages of hits because the winners will be near the top.”

In addition to conducting their own searches, they also asked students to assist in locating resources, as well as subscribing to mailing lists that notified them about pertinent sites. One teacher described her approach:

“all you have to do is get on their e-mail list and they do the research as to the hot educational sites, really good stuff. They e-mail me once a week, and I just look through and bookmark links to the best ones.”

Teachers involved in this study also placed high value in being able to access learning resources that focused on teacher needs, or were built by teachers: “I love going out to teacher sites, I use those probably more that anything else.” They valued knowing what resources other teachers were using in order to gain new ideas and approaches to their own teaching. For example, one teacher frequents web sites that provide teacher-created resources with collected learning resources and links, finding that teacher sites usually provide age-appropriate activities and information that are easy to modify and relate to their state core standards.

When searching for suitable learning resources, the teachers looked for a wide variety of both informational and instructional resources ranging from background information, contact information, graphics, data sets, maps, worksheets, assessments, tools, interactive applications, real-world examples, and links to other sites. Participants found sites that indexed these resources and identified related links were particularly beneficial.
“I particularly like sites that include indexes or tables of contents so that I know quickly what is on the site and where to locate it. I also like sites with printable diagrams, especially simple black and white ones.”

Interestingly, teachers were more inclined to select smaller-grained, isolated resources, than fully developed lesson plans.

“No, I’m not looking for entire lessons. I’m pretty much just searching for the frills and extras.”

“I don’t use the Internet for specific lessons. I look for thing[s] like the latest pictures from the Hubble or little things like that to supplement a lesson.”

In sum, study participants identified the following general criteria for selecting learning resources: age-appropriate, current, accurate, and related to state core concepts in the curriculum. They wanted resources that were simple, with clear instructions that provided an appropriate overview of a topic that students would find engaging and interactive. The teachers looked for the basic building blocks that they could wrap their own instruction around, or extras they could insert into their existing instruction. As described by one teacher: “when you are searching, you are after the interesting extras that you can’t get out of a textbook.”

**Adaptation and use of digital resources for instruction**

The teachers in this study preferred resources that needed little or no modification. They wanted to spend their limited time finding resources and then creating appropriate instructional contexts or wrappers for them: “It is going to take me enough time to search and find and create the link, that I don’t want to mess with modifying a page.” Another teacher described this dilemma: “I end up with several pages of good sites that I have yet to go in to modify to make them appropriate. And there is some good stuff that is right there, I just haven’t found the time to get it all ready.”

The teachers valued resources that were in a convenient format for downloading and adapting for instruction, especially those resources that could be used with little or no modification. One teacher stated: “If I’m modifying a site, I’m usually just grabbing a picture or a little text and usually putting that into PowerPoint. So I need things to be in a fairly common format to work with word processing programs.”

When they did adapt or modify a resource, their activities ranged from simple organization to modification. Organization activities included bookmarking, listing, grouping, or sequencing resources, as well as “creating a mini-tour of websites.” One teacher felt that the ability to “group a few [resources] together with control over the sequence and introductory text is a wonderful [functionality].” Another explained that, “I do have on my page a list of links that are broken down specifically for [the topic of] space or whatever. I also have a main area for our current projects.”

On occasion, study participants made modifications to resources to better meet student needs: “once Internet sites are ‘sifted’ and resources are found, I revamp resources and lessons to fit my instructional time frame and the learning abilities of my students.” In another example, one middle school teacher felt that it was easier to find simple elementary-level resources and augment them, than to modify high-school level resources: “the […] thing that is really nice at the elementary school level is the number of sites that are already built that I can send a student to without having to modify it. I can just put a link on my class page as a reference.”

The teachers also discussed perceived barriers in adapting or modifying resources for their own use. They worried about the time that it would take and the difficulty of modifying a resource intended for another use to fit their own needs. Another concern was around copyright issues and how it might affect their use of digital resources, as explained by this comment: “I think that when I modify, I’m always worried about stealing someone else’s copyright. So the majority of my links are to the original sites.”

**Teacher use of digital resources in and outside of classroom instruction**

Teachers involved in this study used digital resources for both teacher-based activities (e.g., classroom lectures) and student-based activities (e.g., self-paced instruction, home-accessed activities, and student projects).
Teacher-based activities primarily entailed using digital resources for classroom lectures, particularly PowerPoint presentations. “I either: 1) modify and create print-based material, 2) link to a site(s) from our classroom webpage to have students working at that site, or 3) provide information for manipulation and exploration of math topics.”

Teachers also used digital resources as background information for content topics or for possible field trips. “One thing that [I] use the Internet for is data. Data that I can use in my classroom that comes from real life that would relate to them.” Other uses included: whole- and small-group instruction, in-class discussions, content instruction, and real-world data presentation. Occasionally, study participants would use digital resources to introduce topics, tie instruction to the state core curriculum, provide interactive activities, and post student work.

Study participants acknowledged that many Internet resources are “intended it to be used by students rather than the teacher.” Consequently, these teachers encouraged student-directed searches for digital resources in assignments and activities. Students would often access these from home, completing self-paced modules and accompanying assessments. The teachers also had students use web-based learning resources to make-up absences, create projects, individualize student instruction and research, and provide free-time activities. As described by one teacher:

“Yeah, I really like a page that I can just put in. It is nice too because that really serves as an enrichment opportunity to have a link. Then if a student really wants to go crazy on a subject they can start at my site and link to the resource and go nuts with it.”

Tool functionalities

Over the course of their involvement in the study, teachers made several suggestions for improving the functionality of tools for searching for and adapting digital learning resources.

For search tools, the participants wanted to be able to access teacher-focused and generated resources. They also requested resource collections that had already been filtered for education and that included “recommendations tied to specific resources rather than to individuals.” The teachers also wanted their students to be able to access filtered search engines: “I think it would be very cool to have a search engine for kids, without having to worry about filtering. Something that doesn’t post a million and a half commercial things; with accurate, up-to-date, free information.”

It was very important to the teachers that resources be categorized by grade level, content area, and type. One teacher wanted to “see resources grouped by subject, and would love a master list of URLs recommended by other teachers.” They also requested that resources be linked to the state core standards. Furthermore, study participants wanted features that increased accessibility to resources. These included additional information about the types of digital repositories and resources that were available. One teacher indicated that she “would have liked to have been better informed as to what was out there.” Another felt it “would also be nice to go in and say that I’m looking for an activity or a picture, or a specific thing.”

Teachers wanted to download resources in a common format, or one that was compatible with word processors. They also wanted repositories to include indexes or tables of content that facilitated a quick review for location of resources. One teacher “would like a table of contents or glossary for [a digital library] in some type of organization order. And some way to browse that.” Lastly they wanted to be able to preview resources before selecting them for use.

When using and presenting resources, the teachers wanted to be able to use items from a variety of sources, both inside and outside of a particular digital repository. They also wanted to access and combine information from multiple electronic textbooks. One teacher noted, “I mean, we just spent I don’t know how much buying new science books and won’t use more than two chapters out of each one. I mean how great would it be if we could select and regroup chapters from different books.”

For classroom use, teachers wanted to be able to require logins to access certain resources, not only for instructional purposes, but also as a “protected area for testing, grades, other class management stuff, or just whatever.” These teachers also felt that password logins would help them address possible copyright issues.
Limitations of the Study

It is important to note key limitations of the study. First, as is typical in case study method, the study involved a small number of teachers. The purpose of the case study methodology is to delve deeply into areas in which hypotheses are unclear, and to focus on contextual commonalities among participants, rather than differences (Johnson, 1997; Yin, 2003). As such, a small sample size is preferred. In addition, a key data source was focus group interviews. In these settings, while the conversation is rich, it is hard to infer individuals’ opinions.

As noted, the teachers involved in the study were all experienced. It seems possible that less-experienced teachers, regardless of their comfort with information technology, might have different strategies for searching for learning objects. For example, because of their relative inexperience, they may be more inclined to search for larger “granularity” objects, such as lesson plans or units.

In addition, the participants could not be characterized as early adopters of information technology. Instead, their experiences are probably more characteristic of ‘pragmatists’, rather than high-end technology innovators or resistors. These participants are likely to be more skeptical of information technology for its own sake, attitudes that are probably more representative of typical teachers.

Teachers were also involved in our study during a period that school was in session. It is likely that their experiences would have been different had they been involved during a different time period, for example a summer workshop, when time constraints in terms of lesson planning are less pressing (Sumner & Dawe, 2001). These represent variables that merit future research.

Finally, our study was conducted at a time when the participating digital libraries were in the process of seeding and growing their collections. As such, content quality and coverage was uneven. The latter caused a small level of frustration among our classroom teachers as they attempted to search for interesting and relevant learning resources. Nonetheless, the teachers were uniformly enthused about the potential of educational digital libraries, and envisioned a wide range of possible uses for digital resources in learning contexts.

Conclusions and Implications for Design

Much has been made about the great potential that learning objects and repositories may have within instruction. Yet little is known about how target users, in particular, teachers, plan to use such resources. To address this gap, this paper presented findings from a case study of mathematics and science teachers’ practices and desires surrounding the discovery, selection, and use of digital learning resource for instructional purposes. These findings offer a number of suggestions for digital library tool designers, and the Instructional Architect in particular.

In terms of discovery and selection of digital resources, the teachers involved in this study were primarily interested in finding resources that they thought were age-appropriate, current, and accurate. This definition of ‘useful’ learning resources has also been found in other studies of teachers’ perception of resource quality (Sumner, Khoo, Recker, & Marlino, 2003).

Educational digital libraries can and are supporting these desires through the use of item-level metadata, for example, the ‘audience’ and ‘subject’ elements in Dublin Core Education Working Group metadata standard (DCMI, 2002). Organizations and standards bodies are also developing controlled vocabularies for use with these elements. For example, the Gateway to Educational Materials (http://www.geminio.org) project has developed controlled vocabularies to describe a resource’s audience, target grade level, language, and subject. Such vocabularies should help users focus their search, but only if they match terms and concepts used by teachers. In addition, digital libraries, such as the Digital Library for Earth System Education (www.dlese.org) are addressing teachers’ desire for resource accuracy and currency by developing education-specific collection accessioning and review policies (Marlino, Sumner, Fulker, Manduca, & Mogk, 2001).

The teachers in our study employed multiple search strategies, including flexible and broad searches, as well as specific searches, often by age-level and topic. The teachers also expressed a strong interest in the ability to browse the collections. As previously noted, it is possible that these discovery strategies are influenced by where a teacher is in his/her lesson planning process and his/her available time (Sumner & Dawe, 2001). As such, tools must support a variety of discovery strategies to accommodate difference lesson planning style and constraints.
Prior research points to the problem of relying solely on keyword search for resource discovery. Specifically, teachers may have an ill-formed conception of what they are looking for, have difficulty translating an instructional intent into a search query, or may lack understanding of Boolean search syntax and semantics (Soloway & Wallace, 1997; Wallace, Kupperman, Krajcik, & Soloway, 2000). The Instructional Architect currently supports only keyword searches, so means must be added to expand search and browse options.

The teachers also expressed an interest in teacher-recommended learning resources and teacher-created repository of resources. In this way, teachers seemed interested in resources that were pedagogically relevant to their current context, as opposed to generic digital resources. This functionality could be implemented by an automated recommender system (Resnick & Varian, 1997), a popular technology in electronic commerce in which the interests of entire communities are leveraged to provide targeted, personalized recommendations of products or resources to individuals. In related work, we have developed a prototype educational recommender system, which can provide such personalized recommendations of web resources (Recker, Walker, & Lawless, 2003).

Teachers were looking to link resources to the state core education standards. This finding underscores the growing importance of linking collection items to specific K-12 educational standards in the United States. It suggests that metadata standards define elements and controlled vocabularies that enable these linkages to be described in ways that are meaningful to teachers.

In terms of resource usage, findings suggest that teachers in the study were more likely to use learning resources that needed little or no modification, could easily be incorporated into planned instructional activities, and could be used to enhance or enliven an existing instructional activity. As such, these teachers preferred resources whose granularity is smaller than a typical class lesson.

This finding raises important issues regarding the ‘optimal’ granularity of digital learning resources. Granularity can be defined many ways, for example file size or semantic density (as defined by LTSC Learning Objects Metadata Working Group (LTSC, 2000)). Typically, educational digital libraries will catalog resources of varying granularity, from ‘large’ (for example, full courses) to ‘small’ (for example, a simple graphic). The findings of this study suggest that the way in which a digital repository catalogs and displays resource granularity will have a large impact on users’ perception of system utility. They also suggest that resources designers should concentrate their efforts of developing resources with smaller granularity, as opposed to large granularity resources such as modules or even entire courses. Given this focus, tools that support resource composition by teachers also become necessary. This is, of course, the niche that the Instructional Architect is intended to fill.

In the end, it is imperative that digital libraries and tools be easy-to-use, save users time, have demonstrable value, and fit into existing contexts, while not adding complications to teachers’ already busy lives and their heavy workload (Swaim & Swaim, 1999). Otherwise, they risk not being adopted by the majority of users. For example, the teachers mentioned desired functionalities such as secure areas for testing, grading, and classroom management. This suggests that emerging tools must be easily integrated with widely used classroom and learning management systems and standards.

In summary, we believe that there is a strong need for continual, in situ user studies in order to better understand the impact and adoption of emerging digital learning technologies and tools in educational contexts. In particular, as argued by researchers in distributed cognition, the mediational properties of tools can only be understood in terms of their embedding context (Brown & Duguid, 2000; Pea, 1993). Thus, tools offer opportunities or affordances for action, which may or may not be acted upon in any given situation. As such, any complete understanding must include systemic analyses of tools, actors, and contexts, and not simply focus on technological concerns.

Acknowledgments

The work reported in this chapter was partially supported by grants from the National Science Foundation (NSF DUE-0085855 & 0333818) and Utah State University. The ideas expressed herein are not endorsed by and may not be representative of positions endorsed by the sponsoring agencies. We thank David Wiley, Derek Reinke, Andrew Walker, Jaeyang Park, and Ye Liu for their contributions to this work. We also thank the participants in our study. Finally, we thank Joel Duffin and four anonymous reviewers for comments on an earlier draft.
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The «Lesson Sheets» and their Application in the Instructional Procedure

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Abstract
This study concerns the application of tools and methods of Open and Distance Learning (ODL) in the traditional class. More concretely, the design of an instructional aid called «lesson sheets» is discussed, according to specific guidelines, which evolve from the corresponding educational theories. Accordingly, the application of the proposed tool in four classes is described, as perceived by the participating subjects. The results of the study show a good integration of the proposed tool, however its construction must be performed according to the provided guidelines. Finally, some further research aspects are discussed, which are necessary in order to investigate the effective application of this tool in ODL environments as well.

Keywords
Instructional tool, Lesson sheet, Personalization

Introduction
Many instructional aids for activating the participation of learners in the instructional procedure and for solving some of the problems of face-to-face instruction and of the delivery of traditional printed material to the learners have been proposed. This is because learning is a process (Duchastel, 2001) that depends on other features as well, such as learner’s motivation, previous experience and learning strategies that the individual has been supported to develop. The effectiveness of any educational environment cannot be considered independently of these aspects. It is widely accepted that effective learning is also related to educational environments and tools that provide the students with an incentive for active participation in the learning process.

Also, the approach of delivering instruction over distance (e.g. web-based education), unveils the issue of support and scaffold of students, an issue that was always important in all ODL schemes. In such environments, the ad-hoc prepared educational material underlies some guidelines characterized as sound for ODL: aims and targets, keywords, short chapters and paragraphs, simple language, explanation of difficult points, exercises and activities are only some of them. In addition to this, a set of new educational approaches and methodologies has evolved, in order for this material to be smoothly integrated into the instructional procedure. As well as the above, a set of different kinds of learning aids, such as “study frameworks”, time scheduling, and summaries has also evolved. So, it is obvious there is a need for supporting material for the student, in order to «integrate» him/herself easily into the new educational environment. Up to now, all tools proposed aim to scaffold the student in his work and to confront eventual learning difficulties. In this context, Race (1993) for example, suggests a “handout” for use during the instructional procedure and pinpoints some advantages and disadvantages of this tool as well. He argues that the delivery of the same package to all the participants, their active participation, the time profit, the acceleration of noting down information are some strong points of the tool, while the weaknesses include the possibility of the ill structure of the educational material, the diminishment of interest or total loss of interest due to the presence of this tool.

The proposed tool
However, to our knowledge, there is not a tool for use during and after the lesson, clearly aiming to «accompany» the student throughout the whole instructional procedure. So, the motivation of this study was the need to propose a tool that could support and scaffold the student during the lesson, in assisting him/her to capture and personalize the offered information, as well as for use after the lesson during his/her study at home, in assisting him/her in learning, understanding and assimilating the recorded material, thus facilitating his/her augmentation of knowledge on the domain.
The use of the proposed lesson sheet is simple: it is delivered to the students prior to the lecture, they use it during the lecture for noting down information, keeping track of the instruction process and performing the exercises and activities on it (thus personalizing the instruction). Furthermore, they keep the sheet after the lesson for use at home as an archiving tool. At the end of the instructional period (e.g. a semester), the complete set of lesson sheets provides a record and a personalized view of the performed instruction.

Theoretical Considerations

Learning and understanding

Traditionally, the contrast between deep versus surface approaches to learning is based on the learner’s intention to understand or his/her lack of such an intention. These two different approaches are expressed through a focus on the text itself, which the learner intends merely to reproduce (in the surface approach) contrasting with a focus on the underlying meaning of the text, which the learner intends to comprehend (in the deep approach). This contrast implies that memorization, which the learner uses in order to reproduce, is by definition incompatible with understanding. However & Kember (1996) cites a number of studies of Asian learners, which contain evidence to the contrary. Kember & Gow (1990) identified a “narrow orientation” in students who systematically go through sections of the material to be learned, seeking first to understand, and then to memorize. Hess & Azuma (1991) found that understanding in Japanese schools is achieved through repetition and memorization, memorization being used as a technique to assist understanding. Marton et al. (1993) similarly found memorization used as a strategy to reach or enhance understanding. In terms of a chronological relationship between the two processes, this means that three patterns are found:

- Understanding, then memorization (Kember & Gow, 1990),
- Memorization, then understanding (Hess & Azuma, 1991)
- Both the above (Marton et al., 1993).

What is the relation between understanding and learning? Landbeck & Mugler (1994) argue that students learn using two quite distinct methods:

- One to describe the acquisition and storage of information (which they call Learning1 (L1)), a process which does not necessarily imply understanding,
- A second, which refers to the coming to an understanding of the material that has been acquired (which they call Learning2 (L2)).

The information of level L1 normally has to be thought about before it can be understood. Once it is understood, then what students themselves call “real” learning has taken place. The progression from L1 to L2 is illustrated by one student’s words: “Well, learning is something that you get into your mind that’s something new to you in the first place, and you keep it there, you get to understand it and then later you come to use it. I mean it’s always there, it doesn’t go away”. (Landbeck & Mugler, 1994)

However, since learning can be described in more than one dimension, it must be explicitly acknowledged here that there are several other approaches to learning and that the relation between understanding and learning is much more complex that this model suggests. However, in this study the locus has been limited to this issue, namely the transition from L1 to L2.

Novice vs. expert

With the passing of time, the transition from novice to expert is a subject, which has occupied many researchers. It mainly starts with the question “how do we define the novice and the expert user”. Chi et al. (1981) argue that it is not the quantitatively differentiated accumulation of knowledge between two different human categories. What differentiates the novice from the expert is basically the different representations they possess for the entity, and, consequently, for the problems they are supposed to solve. Indeed, a series of studies (Larkin, 1983; Chi et al., 1981) show that the mental representations of the novice are strictly restricted to the surface characteristics of the problem, which is expected, since they are known and familiar. Contrary to the above, experts possess the ability to correlate these surface characteristics to deeper principles, in representations and subtractions of a higher level and proceed to efficient solutions.

Anderson (1995) gives an analytical description of the procedure of the development of the novice to knowledgeable expert for different cognitive domains. However it is Vygotsky (1930/1978) who defined the
“zone of proximal development – zpd”, thus providing (among many other aspects) his explanation of how the augmentation of the knowledge happens. According to Vygotsky, every human finds himself at a particular level of development, where he can solve a set of problems using his own abilities. However, there is a superset of problems the person could also solve with the aid of more competent agents, such as his books or his teachers. According to Vygotsky, this almost mathematical difference between the “level of real development” and the “level of possible development” builds the “zone of proximal development”. That is to say that this zone consists of functions and skills not yet developed, but ready to emerge or just entering the state of maturity. These abilities can be developed on their own as well, however in a slower manner, as long as the person deals with the problems which enhance his/her own experience on the domain. In our particular case, while the user occupies him/herself with the particular system, he/she gains experience, which in its turn is the crossing of Vygotsky’s “zone of proximal development”. Obviously, this zone doesn't cease to exist, but it is translocated further.

It must be stated at this point that, what the meaning of ‘zpd’ actually is, still remains today a matter open to discussion among experts (e.g. Cole (1996); Crook (1994); Rogoff & Wertsch (1984); Wertsch (1985); Wertsch & Tulviste (1992)). As regards this point of view, the described effect could be considered as an empiricist interpretation of ‘zpd’ and could be considered by and large incorrect as it pictures the ‘zpd’ in empiricist terms. There is definitely more to it than the linearity feature suggested by “further translocation” and therefore the dynamic interplay between cognition and culture, the individual and the social, the everyday and the scientific must also be taken into consideration. Moreover, the ‘zpd’ is closely related to instruction and can have no meaning without it: Vygotsky was very explicit in that good instruction precedes and guides development, thus, instruction should not target the actual but the developmental level of the child. However, regardless of these debates, this study focuses explicitly on the aiding and scaffolding factor that this theory implies and as expressed later by the corresponding design principle.

The factor of “meaning”

The basic role in the augmentation of a person’s knowledge and expertise is played by the factor of “meaning”. According to de Gelder (1981) the understanding of an action implies granting it a status. Also, Demetriadis (2000) argues that the student may have less interest, or none at all in learning things that have no meaning to him. To continue, Anderson (1995) claims that for every message, people remember the meaning and not the words or pictures it contains. To summarize, a situation with clear meaning becomes the property of the person more easily. Obviously, the meaning of a situation should be approached from the perspective of the interpreter, namely of the person making sense of the situation. In other words, a situation can have “clear meaning” or not, only from the perspective of the ‘meaning maker’ (the interpreter of the meaning). Yet, one must be aware that the granting of a meaning in every situation is not self-evident. Often one confronts situations that “make no sense”, and these are more likely forgotten. This is true especially in the case of novices. Pressley et al. (1987) argue that, because they lack the overview of every situation, they are not always able to elicit the appropriate information in order that the situation acquires meaning in the person’s context and becomes easily memorable.

Motivation

The last issue to be considered is motivation, which is another important factor concerning educational design. The term motivation refers to the choices people make as to what experiences or goals they will approach or avoid, and the degree of effort they will exert in that respect. (Keller, 1983). Aubé (1997) also studies the role of emotions, needs and available resources. He claims that motivation has as its ultimate aim the ideal resource manipulation for benefit of the person. A “resource” is considered to be everything that could contribute to the achievement of a level of completion, be it by natural means (temperature, food, power, etc) or immaterial (time, knowledge, relation etc). Finally, as regards the measuring of the person’s motivation, Demetriadis (2000) argues that we have to consider the amount effort made by that person and not the level of success. Also considered are the emotions one perceives during the procedure, regarding the task one feels one has to fulfill.

The motivational theory of Keller

The motivational approach followed in this study adheeres to the four-factor-theory, stated by John Keller (1983). According to this researcher, motivation can be analyzed into four distinct factors:

- **Interest** refers to whether the learner’s curiosity is aroused and whether this arousal is appropriately sustained over time.
The Design Principles

In order to apply these theoretical aspects, some corresponding “design principles” must firstly be stated so as to facilitate the design procedure. Therefore, these design principles must be considered as a middle step towards the materialization of the theory. They should not be considered as theoretical principles, possibly proposed by other researchers; they are just design principles.

- **Facilitate the transition from “understanding” to “learning”**. This can be achieved in a variety of ways. By accelerating the procedure with the removal of routine tasks (e.g. copying from the blackboard), or by providing some “simple” information on the sheet, such as definitions (requiring only memorization), item lists (requiring common sense), or simple notions (maybe already partially known). In addition to this, a visible structure, such as a table shape with lots of visual representations of the offered information should be used. The “gestalt” laws provide here the best evidence that correctly placed (or misplaced) visual representation affects perception and interpretation. Wertheimer (1923) studied perceptual grouping. What is most important about his work in the present context is that Wertheimer attempted to see what our mind does against a consideration of what our mind might have done. Wertheimer explores the way we typically perceive group elements. However, in order to determine whether the mind is exerting a “bias”, he considers some of the ways these same elements could have been grouped but weren’t. The behaviorists typically weren’t this analytic. Consequently, it was the gestaltists that kept trying to point out these annoying problems that can arise when one is a bit more analytic about what one is up to. In the context of this study, the correct shape and placement of items on the lesson sheet, in other words its graphic design, is argued to be of importance. However, even more important in facilitating the progression from understanding to learning is the activation of the student. Therefore, apart from its correct graphic design, the tool must provide an adequate number of exercises and activities, which the student is asked to perform.

- **Assign meaning to the offered information**. Personalization is the key word here. So, adequate space is necessary, in order for the student to keep his/her own notes along with a clear structure, and self-assessment facilities and activities. The individualized feedback from the teacher to each student is important here although it is difficult to materialize. This is a pillar of ODL, which however is difficult to apply in a traditional class, due to lack of time resources during the “live” lesson. Though, a sophisticated modified lesson sheet could provide such an alternative, namely the individualized teacher’s answers to an exercise or activity.

Table 3 in Appendix B summarizes the relation between theoretical aspects, evolving design principles and corresponding construction guidelines (in the table cells), which will be discussed subsequently.
The Construction Guidelines

According to these design principles, a set of construction guidelines can now be stated. It must be emphasized, that they are not on a one-by-one correspondence to the principles, since construction guidelines aid the construction of the sheet rather than theoretically explain it. For example, design principle 1 states that the graphic design of the tool must be sound. So, construction guideline 1 (below) states that the tool must take the shape of a table. Another example is the need for personalization (design principle 3), so construction guideline 4 argues the need for adequate free space on the right-hand side of the sheet.

Interested readers, who want to match the principles and the guidelines provided below, can refer to the aforementioned Table 3 in Appendix B. Below are the proposed construction guidelines. The “Lesson Sheet”:

1. Utilizes the shape of a table in order to frame and structure the offered information.
2. The left hand side contains the offered information in terms of “titles” and “paragraphs”. In fact, this left hand side provides the outline for every lesson.
3. There must be adequate recall of situated knowledge: an already known definition, or image, or graph, etc.
4. On the right hand side of the sheet the student can note whatever he/she wants, corresponding to the pending paragraph, thus personalizing the lesson by the use of the learner's comments.
5. It includes images, figures, charts, and whatever else is appropriate to visualize the information.
6. Notifications that are not personalizable, e.g. Internet links, tables, additional or external information and resources must be provided on the sheet, even if they belong to the sphere of the students’ notifications. This accelerates the procedure and diminishes the distraction that occurs during the students’ noting time.
7. The left hand side includes the necessary self-assessment exercises and the activities the student has to perform during the lesson, while the corresponding space on the right is usually reserved for the answers. Exercises of gradual difficulty must also be included.
8. Provide immediate (after reasonable time) feedback on self-assessment exercises, in order for the student to correct his/her mistakes.
9. Provide text and theory of no more than 2-3 paragraphs for every “chunk” of information. Subsequently, an alternative must be provided be it an exercise, an external resource, or a student activity.
10. It must be sound in its size: the application of the sheet has shown that 4-5 pages are sufficient for a 3-hour lesson. In addition, good image quality and high quality printing is imperative.

In Appendix A there is a sample sheet that has been used during one of the courses reported here. It must be emphasized that it has been simplified, reduced to a two-page lesson sheet that can, and must, be expanded to its full potential as described here. The purpose of this sample is only to illustrate what has been reported on this work.

Studying the tool in practice

The tool has been applied in four different classes.

➢ One postgraduate class of students studying Open and Distance Learning at the Pedagogic Department of the Aristotle University of Thessaloniki.
➢ Two classes of secondary education teachers; they were taught the application of ICT (Information and Communication Technologies) in the instructional procedure (use of computers, educational software, web design, educational web-sites etc.)
➢ One class of secondary education teachers; they were taught basic skills in computers (computer literacy).

It must be emphasized here, that to report from classes on different cognitive domains is an unusual approach. No conclusions on the effectiveness of the tool concerning the acquisition of information can be drawn, since there was not a control and a treatment group on every domain. Nevertheless, this study concerns how the students perceived the application of the tool during the instructional procedure and their satisfaction grade. In line with this point of view it can be argued that all classes had some shared characteristics. They all consisted of adult participants, studying at postgraduate level. All classes consisted of about the same number of participants (approximately 12), lasted about the same duration (one semester) and the students were complete novices in the taught domain. All participants were volunteers; subjects who refused to use the tool (approximately 2-3 in every class) have not been included in the results.

During the whole period the students worked with the lesson sheets and at the end they participated in a survey evaluation with a questionnaire and some attended an interview (as described later in the section “the interviews”). In order to be able to statistically elaborate the data, the questionnaire consisted of closed type questions, which were answered on a lickert scale as described below.
Accordingly, an ANOVA test has been applied, in order to prove the correlation of the answers, as described in the corresponding sector. Finally, the results have been summarized to report a “mean” of all participants’ opinions on every particular question.

The questionnaire

The questionnaire consisted of three parts. The first part consisted of general questions, concerning the application of the questionnaire and the cognitive transfer due to its application, as perceived by the participants. The pending questions were:

**Part 1**

1. Did it (the «lesson sheet») make the structure of every lesson clear? (L1 -->L2 & satisfaction)
2. Did it help you to keep track by using notes during the lesson? (L1 -->L2 & expectancy)
3. Did it help you during the revision at home? (Scaffolding)
4. Do you consider this tool as an «archiving tool», namely, if you browse through these sheets at a later time, do you think they can remind you of the lesson material? (Scaffolding & outcomes)
5. To what grade does it recall the lesson to you? (Meaning & relevance)
6. To what level do you consider the whole application of the «lesson sheet» as successful?

The expressions in the parentheses were obviously not on the questionnaire; they are stated here to clarify the locus of every question.

**Part 2**

In the second part of the questionnaire, the participants were asked about the advantages and disadvantages of such a tool, according to Race (1993). The intention was to investigate if Race’s claims are still present in the proposed tool. Race considers the below as advantages (and the participants have been asked about their opinion):

1. The fact that every student gets the same educational «package»
2. The students do not need to note passively or copy from the board.
3. The students have more time for the content of the lesson, instead of dealing with noting
4. Whoever writes slowly is not so disadvantaged as he profits from the tool
5. Whoever has language or comprehension problems, or assimilates slowly, has now more time to think about the taught material.

**Part 3**

The participants were also questioned about their opinion of the disadvantages, according to Race:

1. The students may lose interest, because the sheet contains everything they need to know.
2. They may not come at all, as they know they can have copies of the material.
3. There can be too much material or not enough.
4. Sometimes such aiding tools cannot substitute the personal involvement of the students.
5. One does not feel «in possession» of material that is delivered to everybody (and was not produced by oneself by keeping one’s own notes)

To record the participants’ opinions we used «bipolar semantic differentiated» expressions (Shneiderman, 1998), assessable on a five gradation lickert scale. Example:

3. Did the sheet help you during the revision at home?
   (1) No, not at all (2) (3) (4) (5) It was the main means

Appliance in practice

During the appliance of the tool similar behavior in all classes was observed. This observation is of course only an empirical one, as the instructors perceived it. As expected, at the beginning of the courses, all students needed some assistance in using the tool, however it soon became transparent in its use and the participants did not have any further problems. However, during the first lessons the instructors had to repeatedly remind the students of the presence of the tool and urge them to keep their notifications on it. After the second lesson the students got used to the tool and no more prompting was necessary.

No side effects were recorded that could be of interest to this study.
Statistical elaboration

The ANOVA examination

The claim that the taught cognitive domain can be excluded from consideration, implies that the subjects really concentrate their answers only on the application of the tool (as they have been asked to do), which in its turn leads to the claim that an Analysis of Variance (ANOVA) statistical test would not provide statistically significant differences between the answers of the four classes. This is the null hypothesis, H0, the alternative Ha being that there are statistically significant differences between the answers of the four classes. Figure 1 in Appendix B shows, as an example, the examination of question 1 for significance level $a=0.05$.

Table 1 summarizes the findings of the test for all questions on the questionnaire.

**Table 1: Summary of the ANOVA test for all questions**

<table>
<thead>
<tr>
<th>Question</th>
<th>a1</th>
<th>a2</th>
<th>a3</th>
<th>a4</th>
<th>a5</th>
<th>a6</th>
<th>b1</th>
<th>b2</th>
<th>b3</th>
<th>b4</th>
<th>b5</th>
<th>c1</th>
<th>c2</th>
<th>c3</th>
<th>c4</th>
<th>c5</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.22</td>
<td>0.99</td>
<td>0.68</td>
<td><strong>0.01</strong></td>
<td>0.65</td>
<td>0.16</td>
<td>0.18</td>
<td>0.91</td>
<td>0.21</td>
<td>0.68</td>
<td>0.46</td>
<td><strong>0.04</strong></td>
<td><strong>0.03</strong></td>
<td>0.31</td>
<td>0.40</td>
<td>0.88</td>
</tr>
</tbody>
</table>

As one can notice, there are three questions that do provide a significance level lower than $a=0.05$. So, the null hypothesis must be rejected for these questions, and the alternative adopted instead, namely, there are statistically significant differences between the answers of the four classes. Accordingly, these questions must be excluded from further elaboration and must also not contribute to the results. However, for comprehension reasons, in the following diagrams and tables all the questions are presented, yet the aforementioned problematic questions have not been considered in the concluding discussion. These questions are:

- **Part 1 (general), Question 4**: Do you consider this tool as an «archiving tool», namely, if you browse through these sheets at a later time, do you think they can remind you of the lesson material?
- **Part 3 (disadvantages), Question 1**: The students may lose interest, because the sheet contains everything they need to know.
- **Part 3 (disadvantages), Question 2**: They may not come at all, as they know they can have copies of the material.

Elaboration

Statistical elaboration of the collected data was rather simple (descriptive statistics), as there was a sample of about 50 students and the study was not strictly structured. In this phase, the main focus of the study was, as already stated, on the qualitative assessment of the tool as perceived by the users.

Below, Table 2 summarizes the findings from all courses, concerning mean values and standard deviations.

**Table 2: M.V. and St.Dev. of the general assessment**

<table>
<thead>
<tr>
<th>General</th>
<th>M.V.</th>
<th>St.Dev.</th>
</tr>
</thead>
<tbody>
<tr>
<td>quest. 1</td>
<td>4.28</td>
<td>0.72</td>
</tr>
<tr>
<td>quest. 2</td>
<td>4.08</td>
<td>1.02</td>
</tr>
<tr>
<td>quest. 3</td>
<td>3.95</td>
<td>0.95</td>
</tr>
<tr>
<td>quest. 4</td>
<td>3.90</td>
<td>0.70</td>
</tr>
<tr>
<td>quest. 5</td>
<td>4.00</td>
<td>1.00</td>
</tr>
<tr>
<td>quest. 6</td>
<td>4.17</td>
<td>0.63</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Advantages</th>
<th>M.V.</th>
<th>St.Dev.</th>
<th>Disadvantages</th>
<th>M.V.</th>
<th>St.Dev.</th>
</tr>
</thead>
<tbody>
<tr>
<td>quest. 1</td>
<td>3.54</td>
<td>1.13</td>
<td>quest. 1</td>
<td>4.03</td>
<td>1.11</td>
</tr>
<tr>
<td>quest. 2</td>
<td>3.98</td>
<td>1.18</td>
<td>quest. 2</td>
<td>3.28</td>
<td>1.18</td>
</tr>
<tr>
<td>quest. 3</td>
<td>2.87</td>
<td>0.98</td>
<td>quest. 3</td>
<td>4.16</td>
<td>1.06</td>
</tr>
<tr>
<td>quest. 4</td>
<td>2.98</td>
<td>1.09</td>
<td>quest. 4</td>
<td>3.95</td>
<td>1.19</td>
</tr>
<tr>
<td>quest. 5</td>
<td>1.95</td>
<td>1.16</td>
<td>quest. 5</td>
<td>3.87</td>
<td>1.07</td>
</tr>
</tbody>
</table>

The mean values (M.V.) and the standard deviation (St.Dev.) were considered:
- The mean is recorded in a 1 to 5 scale, corresponding to the lickert scale
- Concerning the standard deviation, a great deviation from value 1 means disagreement, while concentration around value 1 means coincidence.
Interpretation of the results

First Part (general assessment of the «lesson sheets»)

In studying Table 2, part 1, it can be elicited that the students perceived the sheet as a fair tool, with all mean values greater than 3.9. Their opinion was especially positive as regards it keeping the structure of the lesson clear (question 1), while in question 5 (to what grade does it recall the lesson to you?) an absolute unanimity can be observed (1.0). There is also a high mean value (4.17) in the question for the overall assessment of the tool (question 6), yet here there were some objections (outliers) that placed the standard deviation in 0.63.

Second Part (Advantages)

In studying Table 2, part 2, it can be elicited that the participants agree (M.V. greater than 3.0) with questions 1 and 2 (the fact that every student gets the same educational «package» and that the students do not need to note passively or copy from the board). However, there is no agreement (M.V. less than 3.0) on the rest of the suggested advantages. Question 5 (whoever has language or comprehension problems, or assimilates slowly, has now more time to think about the taught material) provides a mean even lower than 2. Concerning the unanimity of these answers, the standard deviations are around value 1.0, which means that there is almost total agreement.

Third part (Disadvantages)

In studying Table 2, part 3, it can be elicited that a respective unanimity for all questions is present (M.V. all greater than 3.28) with a respective agreement as the standard deviation is around value 1.0.

However, questions 1 and 2 of this part («the students may lose interest, because the sheet contains everything they need to know» and «they may not come at all, as they know they can have copies of the material») failed the ANOVA test and must be excluded.

Summary

The elaboration of the questionnaires shows a fair acceptance of the tool by the participants, as the summary of part 1 shows. They partially agree on the reported advantages of such a tool, yet they almost totally agree with its reported disadvantages, even if 2 questions are excluded. In the section “conclusions” there is a more inclusive report on the findings of this study.

The interviews

The context

The problem in adult education regarding the evaluation of used instructional approaches is that participants are not always eager to participate in an evaluation. In the study under consideration the questionnaire has been considered as the most important means of collecting data. The interview has been considered as an alternative source of information, so the approach of a totally unstructured interview was utilized because a structured interview approach would possibly create protests. So, not all participants were asked (approximately half of them) and not at fixed appointments. Educators spoke randomly with participants about the tool and noted their comments at the end of every lesson. The main point of concern, which is the central question in this study, was how the participants perceived the application of the tool in practice. Therefore no other aspects, such as the ideal shape of the tool or the scope of its application, were recorded. Thus it is believed that it reduces the bias of the educators and the noting delay. Namely, after the lecture (or during a break) the educator remembers and makes rough notes only on the discussed aspects and the expressed opinions. Due to this validity threat inside the nature of the unstructured interview approach, the interviews have been considered as a secondary, yet valuable source of information.

According to this point of view, no elaboration of the collected data could be performed. Consequently, only a rough grouping of the more common opinions and the pinpointing of some interesting viewpoints are presented in the results below. On the other hand, qualitative research merely seeks to describe a situation in whole, rather
than to calculate distinct parameters. So, the results of the unstructured interviews are considered to be a qualitative supplement to the already presented statistical findings of the questionnaires. These, in turn, aim to further clarify the personal feelings of the participants during their occupation with the proposed tool.

**Results**

The results of the interviews were disappointing to a degree. This is because almost all the questioned subjects expressed themselves enthusiastically about the use of the tool and argued that it helped them to assimilate the information. Some of them added the word “to store”. Most of them also noted that it helped them to “keep good track” and not delay during the lesson, because of the fact that the most important points of the lesson were recorded on the sheet.

They also argued that the sheets encouraged them to organize their home study, as the lesson plan was clearly marked on the sheet. They also believed the sheets to be helpful in cases where they needed further study on a particular topic. During the interviews, some also disagreed with disadvantage 5, arguing that eventually everybody constructs his/her own knowledge, enhancing the “main corpus” that is provided in the lesson sheets with individual notifications, in turn personalizing the offered information.

It is worth mentioning that no negative assessments were observed. Although one could argue that such a consensus leads to a lucid result, it can also be argued that the factor of bias emerges here as an important threat. Psychologists have done some interesting studies on this point.

Maier (1931) had people try to solve the problem of tying together two pieces of string that hung down from the ceiling too far apart to be grabbed at the same time. One solution was to tie some kind of weight to one of the strings, set it swinging, grab the other string, and then wait for the swinging string to come close enough to reach. It's a hard problem, and few people came up with this or any other solution. Sometimes, when people were working, Maier would “accidentally” brush against one of the strings and set it in motion. The data showed that when he did this, people were much more likely to find the solution. The point of interest for us is, what did these people say when Maier asked them how they solved the problem? They did NOT say, “When you brushed against the string that gave me the idea of making the string swing and solving the problem that way”, even though Maier knew that's what really happened. So they could not and did not tell him what feature of the situation really helped them solve the problem.

So, these opinions of the subjects recorded through the interviews can be considered as tentative; they are relatively easy to validate with the aid of a controlled experiment, which is proposed in the “further research” section.

**Conclusions**

It can be argued that this modified “lesson sheet”, as described and proposed in this work, has been positively accepted by the students. In particular, the qualitative comments from the unstructured interviews provide support for continuing with the study of the tool. The point here is whether the enthusiasm of the participants corresponds to the real efficiency of the tool.

A second conclusion is that the participants in general agree with Race’s claims about the disadvantages of such a tool. They only partially agree with the stated advantages, which they don’t seem to take very seriously. This obviously confronts their expressed enthusiasm, or it can be interpreted that they perceived some other advantages, not stated by Race. So, the question arises as to whether the tool provides some other advantages, not yet revealed. However, this question was not in the scope of the present study and cannot be answered. In addition to this, the interview did not provide any evidence on this aspect.

The presented conclusions up to now show certain confusion on advantages and disadvantages of such a tool, as its users perceive them. This fact means that every participant interprets advantages and disadvantages in a very different way. So, there is no clear conclusion on this side of the tool, although the overall good impression of the first part approves its application in general.

In conclusion, the adherence to the presented guidelines is considered to be important, in order for the tool to be effective, at least until some of them are abandoned or modified, due to results from future relevant studies. The
final aim is to provide a tool derived from the domain of Open Learning to be applicable in the traditional class and finally to import it in ODL environments as well. These first results are encouraging in this direction.

Concerns

As a whole, this study is more practice driven than theory driven. It has neither specific research questions to address nor is it aimed at testing hypotheses derived from a particular theory. However, qualitative studies, especially on how users perceive various educational approaches, are valuable, because they provide evidence that measurements and controlled experiments cannot. As regards this point of view, this study proposes an instructional tool, suggests guidelines for its construction and reports on its application in four classes. So, only one major question has been set during the study: “Is it worth applying this tool?” The main reason for reporting on the results was the high level of enthusiasm of the majority of the participants. This was expressed enthusiastically with one woman’s words during the interview: “Finally, I have spared hours of noting! Why hasn’t any other instructor ever thought of something like this?” (Her words)

Yet, there are some more concerns about the acceleration factor. In Table 3. in Appendix B, there are two ( - ) signs for ‘zpd ’ and meaning. It can be argued that accelerated noting of the offered information neither facilitates the scaffolding of the student in building up his/her own knowledge (under a constructivist point of view), neither assigns any meaning to the offered information; the student simply does not have the time for it. This issue was not investigated during this study and remains open.

It must be emphasized once more that the cognitive domain varied throughout the study, so the reported results must be considered independently of it; that is only at the level of the tool’s application and not at the level of the facilitation of any cognitive augmentation.

Further Research

Further research must focus on the issue of the validation of the results of this study with a formal experiment, e.g. as proposed by Wohlin et al. (2000). The use of a control and a treatment group on the same cognitive domain can provide information on whether the perceived performance of the tool by the participants of this study corresponds to the measured data concerning real performance on the cognitive domain.

Secondly, the tool has only been applied to adults, since its origin is in Open Learning. However, it would be interesting to see whether such a tool could confront some of the problems which children encounter during instruction, such as distraction, impatience, or thought fragmentation. This issue also remains open.

Finally, the adaptation of this tool to ODL environments is the next challenge. Although it seems relatively easy to adapt it in ODL, many other factors must be considered. For example, one aspect is the definition of its new form and the mode of use of the modified tool by ODL students. Here an approach could be to present it during the first tutorial session, assuming it is an ODL program that utilizes tutorial sessions. Another aspect is the enhancement of the proposed guidelines for adaptability to ODL, as well as dealing with the difficulty in evaluating the tool due to the dispersion of the students. Finally, one has to ensure its use by the students up to a certain point. In conclusion, a modified “lesson sheet” for Open and Distance Learning could contribute a great deal in the direction of student support and the scaffolding of his/her home study. These two issues have been recognized as the number one threatening factor leading to the abandonment of studies up to a percentage of 30%.

References


### The Hardware

<table>
<thead>
<tr>
<th>The basic parts of the computer</th>
<th>(This PowerPoint or Multimedia Presentation is downloadable at <a href="http://www.anadress.com">http://www.anadress.com</a>)</th>
</tr>
</thead>
<tbody>
<tr>
<td>The computer peripherals</td>
<td>(This PowerPoint or Multimedia Presentation is downloadable at <a href="http://www.anadress.com">http://www.anadress.com</a>)</td>
</tr>
</tbody>
</table>

**Practice (30 minutes):**  
*Anatomy of a Computer* (teacher «operates» a computer)

**Self-assessment 1.**  
Suppose, You’ve been asked to construct a computer with only the absolute basic parts. What would you choose?  
*Write in this space*  
*(Discussion will follow…)*  

Personal Computers, mini, mainframes, supercomputers, etc., etc

### The Software

**Programming languages:**
- The 5 generations
- The more common languages
- Languages of the Internet

**The Operating System - History**

Further Information at:  
http://www.1stadress.com  
http://www.moreadresses.edu

**The Operating System – Structure**

**Self-assessment exercise 2.**  
In which tasks the operating system takes part?  
*Note at the right*  
*(Discussion will follow…)*

- [ ] [ ] [ ] Word Processing  
- [ ] [ ] [ ] Printing  
- [ ] [ ] [ ] File copying  
- [ ] [ ] [ ] Sound processing  
- [ ] [ ] [ ] Connection to the Internet

**Office software**

**Graphics and multimedia software**

**Other software**

**Activity 1**

*Classify the software on Your disk!  
Categorize it. At the next lesson You’ll compare it and discuss it with Your class neighbors (right and left).*  
*(Activity 1 of the next lesson)*
### Computer Networks

#### Classification
- Switched and Broadcasting Networks
- Spatial classification (LAN, MAN, WAN, Internet)
- Bandwidth (simple, ATM’s)
- Application oriented (Dedicated etc)
- Rules and Ethics
- Hardware and Software

#### LAN, MAN, WAN, I-net

Self-assessment exercise 3.
Provide 2 examples of public networks
You can classify. Explain why.

Note at the right -->
(Discussion will follow…)

#### Architecture
- Bus
- Ring
- Star

#### Transmission media
- Coaxial cable
- Twisted pair
- Fiber optic

#### Internet

Structure of the Internet

Internet services and protocols
- www
- e-mail
- news
- ftp

#### Final Activity
Seek information in Internet itself! Describe these services in Your own words, one paragraph each.

Send Your work to the Tutor before next lesson!

Lesson Notes:
Table 3:
The relation between theoretical aspects, design principles and construction guidelines (in the cells)

<table>
<thead>
<tr>
<th>Principle</th>
<th>Theory</th>
<th>L1 $\rightarrow$ L2</th>
<th>zpd</th>
<th>Meaning</th>
<th>Motivation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Easy to use</td>
<td>Table shaped</td>
<td>•</td>
<td>• Clear structure</td>
<td>Satisfaction</td>
<td></td>
</tr>
<tr>
<td>Understandable</td>
<td>Visual representations</td>
<td>• Explaining difficult issues</td>
<td>•</td>
<td>• Nice-looking</td>
<td>Not too long</td>
</tr>
<tr>
<td>Acceleration</td>
<td>Simple information</td>
<td>• ( - )</td>
<td>• ( - )</td>
<td>Relevance</td>
<td></td>
</tr>
<tr>
<td>Activity</td>
<td>Exercises - activities</td>
<td>• Self-assessment exerc.</td>
<td>• Self-assessment exerc.</td>
<td>Interest</td>
<td></td>
</tr>
<tr>
<td>Scaffold</td>
<td>Complex information</td>
<td>• External information</td>
<td>• Self-assessment exerc.</td>
<td>Satisfaction (outcomes)</td>
<td></td>
</tr>
<tr>
<td>Personalization</td>
<td>Immediate feedback</td>
<td>• Adequate space</td>
<td>• Activities</td>
<td>Relevance</td>
<td></td>
</tr>
<tr>
<td>Feedback</td>
<td>Assimilation control (e.g. summarizing exercise w. feedback)</td>
<td>• Self-assessment exerc.</td>
<td>• Activities with feedback</td>
<td>Expectancy</td>
<td></td>
</tr>
</tbody>
</table>

![Figure 1: ANOVA test for question 1.](image-url)
Abstract
In this paper, we suggest that case-based resources, which are used for assisting cognition during problem solving, can be structured around the work of narratives in social cultural psychology. Theories and other research methods have proposed structures within narratives and stories which may be useful to the design of case-based resources. Moreover, embedded within cases are stories which are contextually rich, supporting the epistemological groundings of situated cognition. Therefore the purposes of this paper are to discuss possible frameworks of case-stories; derive design principles as to “what” constitutes a good case story or narrative; and suggest how technology can support story-based learning. We adopt video-based Computer-Supported Collaborative Learning (CSCL) technology to support problem solving with case-stories learning scenarios. Our hypothesis in this paper is that well-designed case-based resources are able to aid in the cognitive processes undergirding problem solving and meaning making. We also suggest the use of an emerging video-based collaborative learning technology to support such an instructional strategy.

Keywords
Case-stories, CSCL, problem solving, social-cultural psychology

Introduction
I remembered a lesson once that I taught about reporting skills in English. As the pupils did not have a similar experience, I brought in an 8-min video clip of “The Titanic”. It featured the ship sinking and the terror the passengers faced. The pupils were then able to “see” for themselves a disaster in action. The lesson achieved its objective and the pupils could write a report on that disaster and in fact, they even interviewed one another, pretending to be the survivors of that disaster. Those pupils have left school already for the secondary education, but they could still remember this episode of their life and often remarked about it being so “real”. (Abstracted from a teacher’s reflection log)

Constructivist learning pedagogies have been increasingly gaining attention in the last few years. Several related instructional models have appeared, the few prominent ones include the constructivist learning environment (Jonassen, 1999), goal-based scenario (Schank, 1993/1994) and anchored instruction (Cognition and Technology Group at Vanderbilt, 1990, 1993). These models have few striking similarities: using authentic problems as the learning focus; using technology to support the learning process; and using stories, cases, or scenarios to provide the contextual information. However, the issue of what makes a good stories or cases is not elaborated. In this paper, we propose the adoption of Burke’s dramatic model (1969) as a guide for designing good stories in relation to problem solving.

Stories have been shown to be potentially effective for clarifying uncertainties and problem solving (Hernandez-Serrano & Jonassen, in press) as they provide some form of ‘narrative intelligence’ that is found in cultures (Randall, 1999). Learning psychologists believe that stories are stored in our long term memory as episodic memory (Tulving, 1993) which are indexed by space and time and encoded with contextual information. Episodic memory is proposed as a complement of semantic memory. Episodic memory consists of episodes and events and temporal-spatial relations among these events. Episodic memory is therefore responsible for recalling larger pieces of information, such as scenes or stories. The memory organization or episodic case memory is the
most important aspect in designing efficient case-based reasoning. It should reflect the conceptual view of what is represented in the case, taking into account the indexes that characterize the case (Kolodner, 1983).

Some psychologists are even arguing that acquiring an experience indirectly, by listening to and understanding a story of what other people go through is tantamount to experiencing the phenomenon oneself (Ferguson et al., 1991). Therefore, presenting the experiences of skilled problem solvers in any field to novice problem solvers in that field can provide learners with important scripts about how to solve problem. Case libraries made available to students while they are learning or problem solving can scaffold memory by providing representations of experiences that learners have not had (Hernandez-Serrano & Jonassen, in press).

**Problem Description**

The problem which we would like to highlight in this paper is that most literatures do not specify what makes a good case or story. The justification for cases or stories suggests that stories are able to help learners interpret them in new situations, applying the principles which undergird these cases. Reasoning from stories or cases supports “inferences necessary for addressing the kinds of ill-defined or complex problems that come our way in the workplace, at school, and at home” (Kolodner, 1997, p. 58). Our aim is to describe a framework as to what constitutes a good case or story for problem solving. The use of stories in problem-solving education increases problem-solving skills, helps address misconceptions, and contributes to the changing of attitudes (Brown, 1992). Therefore the purposes of this paper are to:

1. discuss Burke’s framework on stories;
2. derive design principles as to “what” constitutes a good case story or narrative; and
3. suggest how technology can support story-based learning.

**Narratives as Instructional Tools**

Social cultural psychology emphasizes that the use of narratives, stories, and historical accounts of one’s culture can significantly impact on the notion of cultural epistemologies and beliefs. Stories and narratives are ‘instructional’ tools for teaching values and morals (see Vitz, 1990). As such many educationists have adopted the traditional view that stories, myths, poems, and other narrative material as powerful models for values education of the young (e.g., Tappan, 1998). Stories also help to make sense of people’s lives in a cultural setting (Kilpatrick, 1992).

We are suggesting that there should be more research as to how narratives can be used through educational tools via media such as the Internet. Narratives and stories are a powerful means of instruction because the learner can associate with the context, plot, characters, and elements manifested in them. Basically, one of the ways instructors can scaffold learners through the societal Zone of Proximal Development (ZPD) via the use of narratives and stories, embedding different voices and perspectives (Matsumoto, 1996). Narratives are one means to connote activity (cultural) systems in context. Activity systems try to depict the human agents involved, the tools used in mediating tasks to be achieved based on purposes, and the rules and division of labor involved (Jonassen & Rohrer-Murphy, 1999).

According to Vertsch (1998), the basic cultural tool for generating the historical representations is language. In particular, he focused on narratives as a particular form of language used in history. Bruner (1996) similarly advocates the use of narratives, where they can be interpreted based on hermeneutical principles. According to Bruner (1996), the “narrative construal of reality” (p. 130) contains notions such as (a) a structure of reality, (b) generic particularity, (c) actions have reasons, (d) hermeneutical composition, (e) implied canonicity, (f) ambiguity of reference, (g) inherent negotiability, and (h) the historical extensibility of narrative. These notions are important because learning is not the same as merely learning the subject, but rather the culture of the subject with about the ‘narratives’ and attendant non-rational meaning making that goes with it (Bruner, 1996).

From a similar perspective, Burke (1969) uses the notions of drama to connote a context of motives, namely: Act (i.e., identifies what took place, in thought or deed), Scene (i.e., the background of the act, the situation in which it occurred), Agent (i.e., person or kind of person who performed the act), Agency (i.e., what means or instruments was used), and Purpose (i.e., objectives, motives, and goals). Within the above notions, motives are being surfaced and multiple perspectives of interpretation are involved. The starting point of Burke’s ‘dramatistic’ method is that it takes human action as the basic phenomenon to be analyzed. In Burke’s case, the
notion of action is coupled with that of “motive”; he was fundamentally concerned with “what is involved, when
we say what people are doing and why they are doing it” (Burke, 1969, p. xv).
According to Ricoeur (1981/1998), the plot grasps together and integrates multiple and scattered events into one
whole and complete story. The “plot” is a construct of human time (with an intended purpose by the author),
whereas the “story” is a sequence of events, situations, and settings in natural time. The “plot” is a set of
arguments organized in terms of human time, albeit not necessary in sequential historical order. In other words,
we are advocating that case stories are adopted in problem solving with intended purposes or “plot”. Not all
cases are useful in particular instances of problem solving or learning. For the purpose of supporting problem
solving, the central intend of the story adopted needs to be articulated, and designers needs to select stories or
create stories with clear intended goals and motives. In the next section, we propose a set of instructional design
questions based on Burke’s model to create good stories for the intended purpose of supporting problem solving.

What constitutes a good story for problem solving?

Adopting Burke’s dramatic model, we propose the use of Act, Scene, Agent, Agency, and Purpose as essential
components of a good story. A plot constitutes these five notions of Burke’s framework. The following are
guiding instructional design questions for the selection of case stories in any particular contextual situation in
problems solving:

**ACT** – what took place in thought and deed
1. What are the outcomes of the case story?
2. Do these outcomes or acts relate to the problem solving acts of the problem being represented?
3. If the outcomes differ, would the learner be able to make the cognitive associations in order to transfer the
case story into the current problem context being solved?

**SCENE** -- the background of the act, the situation in which it occurred
1. Is the background context of the story case similar to the problem case being presented?
2. If the story context or scene differs, would the learner be able to see the associations?
3. What are the reasons for the choice of scene? Are there a series of scenes which scaffold the learner through
levels of problem solving?

**AGENT** -- person or kind of person who performed the act
1. Are the persons in the story and the functions played similar to the problem solving scenario being presented
to the learner?
2. Would the learner be able to relate the agents in the story to the agents presented in the problem scenario?

**AGENCY** – the means or instruments used
1. Are the tools and means used in the case or story similar to the ones which the learner has to use?
2. If the tools differ, would the learner be able to translate or relate to his or her own context? What kinds or
hints can be provided to the learner?

**PURPOSE** – Objectives, motives, or goals
1. What are the main goals of the case or story which is being adopted?
2. Does the purpose of the story or case tally with the purpose of the problem being solved?
3. Are there multiple goals within the story which will create confusion in the learner?

When designing case-stories, educationalist or instructional designers could adopt the suggested questions, as
posed above, in a relatively structured manner based our framework. These guiding questions would provide the
basis of contextualizing stories within rich and situated contexts.

Case stories and Problem Solving

So, why could stories be used as case supports in problem solving? The issue of transfer in learning, that is
transfer of story or case elements to the problem solving context, is crucial. To Dewey (1933), encountering a
problem is the beginning of real thinking or learning. Dewey (1933) regards the need for clearing up confusion;
of straightening out an ambiguity; of overcoming an obstacle; of covering the gap between things as they are and
as they may be when transformed as the germ purposes of a problem. Thus, supporting the problem solving
process is critical to learning. And hence the use of stories is one way through which parallels are drawn from
facts in the story to the facts as presented in the current problem. The story allows for the learner to engage in compare and contrast between elements of the story and the problem presented.

In the process of problem solving, the learner or learners must inherently draw out the dimensions of the story (Act, Scene, Agent, Agency, and Purpose) with that of the problem. With such a compare and contrast, the learner should then draw the possible implications that the story can contribute to the current situation. The learner should then – following the case-based reasoning approach – develop an explanation of why the story was successful or unsuccessful in the story in addressing the issue at hand. With this explanation or mental model being formed, transfer could be made to the current problem solving context. Thus the process is three-fold:

1. Compare and contrast between story and actual problem adopting Burke’s framework;
2. Draw implications – mental model or explanation-- from the story and relate it to the problem context; and
3. Apply the lessons learned to the current problem being solved.

In other words, the learner has to be a reflective thinker. He or she should be able to identify the similarities and the differences between the case (story) and his / her own problem situation. Due to the different contexts (case story and the problem at hand), the learner has to be able to make the relevant changes or transfer before he/she can apply the “new learning”. Metacognitive thinking is needed in this case. Otherwise, it may be merely a low-level “rule” based kind of learning or transfer.

To sum up, a good case story should be able to show the consequence of an action. In other words, learners when viewing a case needs to connect between the “plot” and the consequences of the plot. A good plot allows the learner to relate to the case situation at hand. In the event that the learner has not seen the relevance of the story, scaffolds within the learning environment should be facilitated to assist the ‘transfer’ process. Problems of relevance and transfer occur when learners do not relate to the Agents, Agency, or Purpose of the case in relation to their own specific goals.

A good case story should also invoke a learner to recall relevant or appropriate experiences or cases similar to the case example (if the learner possesses relevant prior example accounts). These self-reflected may be even more significant to the learner compared with case stories provided by the learning environment. A good case may also help to stimulate the learner to develop appropriate thinking dispositions, for example compare and contrast, relevant to solving the problem. Such thinking dispositions would then help the learner to narrow down the choices or eliminate “wrong” choices. Dewey (1902/1990) refers to the notion of psychologizing subject matter by relating curriculum content to the learners’ experiences and making the learning personal. The adopting of a good case approach which the learner can relate to is a good example of psychologizing the subject-matter with ideas relevant to the learner.

Many issues remain for teachers in preparing good cases and stories for learners. Time is needed by teachers to understand the ‘stories’ (prior experiences) of the learners and relating or psychologizing subject matter in the curriculum with relevant cases-stories. The video-based mathematics problem solving case story as described above is one example of a teacher having spent time in designing the problem solving video. Moreover, students in schools also need sufficiently allocated space and time to work on these cases and stories in problem solving. In other words, they need time to experience their teachers’ attempt to “psychologize” the curricular content (Deng, 2001).

**An Examples of Stories in Problem Solving**

The benefits and positive effects of situating instruction as cases and stories have been shown in numerous studies known as anchored instruction (Bransford & Vye, 1989; Bransford, Sherwood, Hesselbring, Kinzer & Williams, 1990; Cognition and Technology Group at Vanderbilt, 1990, 1992a, 1992b, 1993). We argue that the Jasper adventure series produced by the Cognition and Technology Group at Vanderbilt (CTGV) are motivating because they possess the important elements of good stories according to Burke’s framework. The Jasper series present believable stories set in authentic contexts (scenes) that have interesting characters (agents), challenges (acts), and extensions to a variety of curricular areas. To solve the problems faced b the actors in the stories (purposes), the students find information that was presented as part of the story. The Adventures of Jasper Woodbury materials provide a common context for instruction, an authentic task, and a chance to see that school knowledge can be used to solve real problems.
Extending the success of Jasper series, we suggest the use of stories to support problem solving. For example, to help elementary pupils engaging in a complex mathematics problem of planning the budget of a class outing, we could develop a story video. The scenario is set in a context which is familiar to students, i.e. planning a class outing. The story is believable because it is set in a local school situation which is familiar to the students (Scene). The story begins with the teacher telling his/her class pupils that they have been rewarded with a class trip to a place of their choice for doing well in the examination. The students in the video decide that they want to go to the East Coast for a cycling trip (Scene). The teacher forms a working committee made up of six students to plan for the trip (Agent). One of the planning dimensions involved transportation. Two students in the committee are assigned to source for quotations to charter buses for the trip (Agency). They collect four quotations and using the relevant mathematical concepts, figure out the total costs for each quotation and select the “best” vendor (Agency). The teachers, students, and actors in the video can be real people in the school (Agent). Both relevant and irrelevant data can be thrown into the clip. This is done on purpose for pupils to discuss and select the relevant information to solve the problem. All the similar data needed to solve the problems are embedded in the story (Purpose). Students will be able to review the movie anytime to identify important data by clicking on the rewind and play buttons.

Scaffolding Problem Solving with Technology

Having discussed the design of case stories for problem solving, we shall now focus on the scaffolding role of technology. The notion of scaffolding students to move from their current state of problem-solving competency to a more advanced level has been recognized by Vygotsky (1962). Scaffolding can be achieved in multiple ways, including prompts, hints, comments, explanations, questions, counter-examples and suggestions. The common feature is that the teacher provides the learner with support or assistance necessary to complete a task that would not have been completed without the help. Through scaffolding, the teacher models problem-solving behavior so that students can appropriate and internalize the strategy to become independent problem solvers.

In supporting complex or ill-structured problem solving, it is important to engage the learners in social negotiation to reveal multiple views and perspectives and to select and justify optimal solution based on reasoning and evidence (Jonassen, 2003). Computer-Supported Collaborative Learning (CSCL) offers opportunities for both peer and mentor electronic guidance and feedback that stimulate student discussion and internal reflection. Analysis of empirical studies about the effectiveness of CSCL (Lehtinen, et al., 1999) offer evidence that CSCL environments are helpful for higher order social interaction and as a result better learning in terms of conceptual understanding, metacognitive knowledge, skills and changed beliefs and attitudes. However, technologies that specifically support the use of case-stories are not commonly available. In the following section, we review an emerging video-based CSCL, Conversant Media®, as a possible solution that supports problem solving with case-stories.

Technologies which Support Case-Stories

Conversant Media®, a server-based application software developed by Laboratories of Information Technology (Singapore), consists of a digital video player, some administrative tools, and a collaborative discussion board (Lourdasamy, Khine, & Sipusic, in press). It uses video technology that supports situated learning and historical narratives as it captures audio, real-life video images, and rich contextual information. The use of video can help to gain and focus learner’s attention and facilitate qualitative understanding of the events that are being depicted. Digital videos have the added advantages of rewind and replay of any segments in the video (Duhaney, 2000), and the ability to obtain any frame of still images. It allows the learners to freeze, review, and analyze the video footages frame by frame.

Once the user launches the software and selects a video clip, the screen shows a media player on the left hand portion and a commentary frame on the right hand portion of the screen. Each line in the commentary frame represents the title of a comment, which can be clicked to open and view the comments in the bottom card display frame. Each video has a unique time-code which is inherited by the attached comment. Clicking on the comments title, automatically displays the card and brings the video to the attached frame (See figure 1). Unlike other text-based discussion board, it allows viewers to watch the video footages and attach a comment to a specific location on the video.

While viewing a particular segment of the video, if the user is ready to post a comment, the video can be stopped. By using the “comment” button, a commentary can be created in a dialog box and submitted to the
system. The commentary is recorded and the author (commentator’s name) is displayed along side the title of the commentary. In this manner other users are able to add their own comments or react and reply to other users’ comments. As each comment is added, a mark is drawn at the corresponding time code position on the timeline for playing the video. Over time, it becomes possible to locate “hot spots” on the video where higher densities of comments are located.

Figure 1. A screen capture of Conversant Media

Another feature that attempts to encourage better commentaries is the peer rating system. Every card that is open by a discussant, has to be rated before the user is allowed to proceed. Rating is done on a 1 to 5 scale of overall value and informativeness of the comment. Once the user rates the commentary, he can close the window to proceed to other tasks. The combination of the spatial display of comments attachment locations and the results of peer ratings of the comments allows discussants to keep track of the online discussion. Such an annotation track also allows users to retrieve the records of the commentaries from the database easily.

An Example of National Education with Video-based Narratives and Supporting Collaborative Technology

To concretize the above instructional strategies and supporting technology, we suggest a sample module on National Education (subject related to issues belonging to citizenship and the nation) revolving around the water issues in Singapore for grade 9 students. The following sections relate an example of how teachers can construct lessons on the issues of National Education.

Learning Objectives for the First Lesson

- Describe the major events occurred during the longest water rationing exercise in Singapore from April 1963 to February 1964.
- Describe the impacts on various aspects of life in Singapore.
- Derive the implications about water supply in Singapore and its impact on the country’s progress.

Activities

- Students are to produce a timeline of the major events that happened during that 1963 water rationing exercise; produce a mind map on the impacts on various aspects of life in Singapore; participate in online discussion and write a short essay on the implications of water supply issues in Singapore.

Supporting Technology

- Video Narratives. The video narratives can be produced incorporating Burke’s five scaffolding notions so that beliefs and values can be made explicit and public for consideration. More specifically, a video
narratives on the water rationing exercise in Singapore can be produced (Figure 2), which among other events, including the major events that happened in chronological order (Act), the background information of the occurrence of severe drought (Scene), how the government implemented measures to address the problem (Agent), the use of water rationing measures (Agency), and the rationales for doing so (Purpose). The proposed approach of using video-based narratives is similar to the Jasper experiment (Cognition and Technology Group at Vanderbilt, 1993) where authentic mathematical problems are presented through video in real-life contexts. Students were required to identify the problem and to solve it (in groups).

Figure 2. A video narratives on the water rationing exercise in Singapore in 1963

- **Video-based CSCL**
  Using Conversant Media®, the instructor can provide appropriate feedback by monitoring the students’ discussions. Instructors and teachers would be able to pose relevant and thought provoking questions based on the motives undergirding agents in the context of their actions. As a result of discussions centering on the video-based narrative of some historical event, students may be required to produce their own interpretation of the scene or event. The purpose of such a personal account would be to forge what existed in another person’s account (as envisaged by the video) and constructing one’s own interpretation, or perspective—the process of appropriation (Bakhtin, 1981). Although the proposed video-based narrative on-line environment is designed to exhibit one particular narrative at a time, students may invoke past videos observed (related to the current video narrative at hand) and interject multiple views to produce an account or action.

Fundamentally, the above video-based narrative on-line environment creates a knowledge-construction situation with themes of discussion generated according to Burke’s categories of *act, scene, agent, agency, and purpose*. In other words, each of these categories can be a discussion thread. Within each of the discussion threads, learners can mark (and un-mark) segments of the video that is under discussion and title them with meaningful descriptions. When learners review what was discussed, the marked video segments would be presented according to the discussion nodes.

**Follow-up Activities**
- **After the initiation lesson, a more in-depth study of the issue may ensue.** A class can be assigned the role of a working committee with the over-arching goal of submitting a proposal to achieve sustainable supply of water in Singapore in the next 50 years. A brainstorming session can be conducted during which key strategic actions can be identified. The class can then be divided into sub-committees to explore these key areas. For example, there can be an Education Sub-Committee that looks into strategies to educate the public on water conservation, a Technical Sub-Committee that investigates the various technologies to obtain water from the environment, a Public Utilities Sub-Committee that plans the water-reclamation infrastructure in Singapore, and a Foreign-Affairs Sub-Committee who work out negotiations plans with neighboring countries on supply of raw water.
Conclusion

This paper focuses on designing good stories as case-based resources for problem-centered learning. Based on Burke’s dramatic model, we proposed a set of instructional design questions for each essential component of a good story: Act, Scene, Agent, Agency, and Purpose. We also suggested the use of a video-based CSCL technology to support problem solving with case-stories learning scenarios. However, much research remains for how stories can be an integral part of learning. The social cultural research points to the value of culture’s narratives in cognition. We hope that this paper has in some ways contributed a framework for constructing an effective story for problem solving and meaning construction.

References


Distance Education Students Moving Towards Collaborative Learning - A Field Study of Australian Distance Education Students and Systems

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Abstract
Distance education has been offered to young students in Australia for about 100 years. Recently, information and communication technology has been introduced as a means to improve communication, but not all remote students have access to this new technology. This has made it difficult to arrange collaborative learning for distance-education students. In this student-focused study, more than 40 students as well as teachers and other important persons have been interviewed and observed in schools and on remote farms. Using Activity Theory for the analysis, different contradictions were identified. Lack of technology and access were not the only obstacles. The education was built on a tradition of individual learning, and the technology at hand was not supporting collaboration. However, contradictions may result in ‘expansive learning’ among students and teachers, leading to more of a development towards collaborative learning.

Keywords
Distance education, Collaborative learning, Activity theory, Distance education student

Introduction
Learning is a social activity. This is a central thought within the sociocultural perspective on learning and teaching (Säljö, 2000; Wells & Claxton, 2002). All learning is influenced by the social and cultural situation, according to Vygotsky (1978), including not only teacher and peer students, but also family. In order to understand how distance education (DE) students learn, it is important to take into account their entire situation. (Phelan, Davidson, & Yu, 1997)

A fundamental principle in the sociocultural perspective is that successful learning “takes place through active participation in purposeful, collaborative activity.” (Wells & Claxton, 2002, p. 7). It is essential for students to consider alternative ideas and experiences, which they meet by collaborating with other students. Young persons, in particular, need to meet each other and share experiences in order to develop their personality and relations, as well as a view of the world and cultures. But there is a social dilemma connected to collaborative learning: What is reasonable for one individual might be less rational for the whole group. The result could be “a tension between individual and collective rationality” (Kollock & Smith, 1996, p. 109). There has to be a certain overlap in students’ goals, and they must be willing to try to understand the perspectives of others. (Wells & Claxton, 2002)

The present study was conducted in Australia during seven weeks in August and September 2002. The objective was to find out how DE students take advantage of technology for their communication with teachers and peer students, and in particular whether and how they learn by collaboration. To do this, it was found necessary to get a broad picture of the DE culture in Australia: the whole situation around the students, their reasons for studying at a distance, relations to their family, peer students and teachers, their at times isolated environment; and particularly how this impacted collaborative learning. The reason to choose Australia was that this country, with only 19 million people in 7687 km², has an especially long history, about 100 years, of distance education for young people, in fact from kindergarten to Year 12 (K-12).

By using Activity Theory (Engeström, 1987) as a framework for the analysis, it is possible to describe relationships between students and teachers, as well as instruments, and rules for collaboration. I lean on a definition of collaborative learning, suggested by Dillenbourg (1999, p. 2): “a situation in which two or more people learn or attempt to learn something together”.

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Distance education in Australian high schools

Each of the seven states in Australia has its own education system and DE offerings. This study is based on material collected in three of the states: Western Australia, Queensland, and South Australia. The governments in these states are very active concerning education development at the moment. As an example, the government in Western Australia 1998 launched a curriculum framework for kindergarten to Year 12 (http://www.curriculum.wa.edu.au/default.htm). In The Overarching Statement we find the following text:

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Particular attention is given to the importance of maintaining a holistic view of curriculum, the responsibility of curriculum as a whole for such vital skills as literacy, numeracy and social cooperation, ...
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There are also 13 listed Overarching Learning Outcomes, among which part of Number 12 follows here:

```
Students are self-motivated and confident in their approach to learning and are able to work individually and collaboratively.

They also recognise when collaboration will enhance their work. They work well with others and contribute in various ways, sometimes leading and sometimes following, accepting, sharing, integrating or adapting ideas from others and building on various positions flexibly and responsively.
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In the part about learning and teaching we find the following text:

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Independence and collaboration
Learning experiences should encourage students to learn both independently and for and with others.

Working with peers enables students to be challenged by the views of others, clarify ideas and interpret and use appropriate language.
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These principles and guidelines state both goals and methods for collaborative learning as part of every student’s education. They apply equally to distance as to mainstream education.

The students who attend DE can be divided into three categories (each coded below) according to their objectives for studying at a distance:

- **School-based (S)** - Students living in or near a small town with a school without resources to offer education in all subjects and levels. These students often take some courses at the normal (mainstream) school and some at a distance.
- **Rural home-based (R)** - Students living far away from any school, often at a farm with only one family living there.
- **Other home-based (O)** - Students with medical or other reasons for not going to a mainstream school. Other reasons could be that the family belongs to a religious sect, that the student is imprisoned or is a young mother, or that the student has been expelled from mainstream schooling.

Among my 41 student informants, there were 23 school-based students, 12 rural and 6 other home-based students. Here, I do not include students that I just observed taking part in DE lessons. Most students were at the secondary level. To introduce the reader to the students and their situation three narratives are presented, one from each category. All three have been given another name than in reality: "Steve", "Rita", and "Ofelia".

**School-based student "Steve"**

Steve is a Year-12 student taking a course in accounting at a distance. All the other subjects he studies at a small mainstream school. The school did not have enough students taking that subject to form a class; there is only one more student, and Steve is collaborating with him. They help each other when they have problems, but most of the time he studies alone. There is a slot in the schedule for this subject, just as for all the others. Steve goes to a certain room for DE students where there is a supervisor, helping them with the material and various practicalities. Once a week, Steve has a phone lesson with the teacher and other DE students taking the same
subject on the same level. Apart from that, the main communication means are paper letters. Steve did not use ICT for communication other than finding information on the Internet.

“I used to use the computer, type and send in. I used to email but they stopped that. It was nothing with DE, other students used it for other purposes. --- I use the Internet all the time for statistics and so. Looking for an article. Both here and at home.”

Steve likes this way of studying, because he can pace it as it suits him. He also finds it easier to read and write than to listen to the teacher and learn by listening.

Rural home-based student "Rita"

Rita is studying in Year 12 and this is her first year of distance education. She went to primary school in a town not so far away, travelling each day with her mother who worked in that town. Her first year in secondary school, Rita chose a boarding school in a bigger city far away. But she did not like boarding school and then quit. “I like to be at the farm. And my grades are going up now”. This is how Rita describes her normal day:

“I get up at 6.30 – 7, feed the ducks and the dog. I have breakfast and then go to my office. I don’t follow a set schedule. I have a break when Dad comes in. I work until 3 o’clock and then go out and help Daddy, until 5. And then back to work if I need to.”

Rita communicates with her teacher mainly via phone, but also via letters. The post comes every day--which is unusual on remote farms. She uses a computer mainly for typing. She does not use e-mail much. She has met her teachers at a camp. “Now I can put a face and a voice to them”, she says.

At the beginning of the semester, Rita gets a box full of printed material to conduct her studies. She also gets video and audiotapes. The tapes give some extra inspiration and sometimes answers questions in the material. When she gets stuck in her work, she tries to find an answer in the reference literature or on the Internet. If that does not help, she phones the teacher.

Rita gets a lot of support from her family. They check that she is doing her work and encourages her. What is the best thing with DE? "Being a country person, I can be here and do education," says Rita.

Other home-based student "Ofelia"

Ofelia lives in the farmlands but close to a town. She got sick a few years ago and the doctor told her to do distance education. Now she is in Year 10 and doesn’t want to go back. “You don’t get distracted”, she says. She has phone or email communication with her teachers almost every day, asking questions about her work. And her mother helps her to understand the questions and to keep on working. “It would be difficult without a home tutor. If she didn’t tell me, I wouldn’t work all day”, says Ofelia. She does not miss the contact with classmates. Ofelia chats with remote friends now and then and she also does sports together with other kids in the town. The school gathers students for camps or mini-schools every term.

Research methods and theory

A qualitative approach

By visiting their homes, meeting families and taking part in lessons, I tried to get close to the students, building an understanding of their situation. I applied ethnographic methods for the data collection through interviews and observations of 41 students, plus 11 DE lessons. I also interviewed several teachers, administrators and technicians that developed course material. Home tutors are also important persons for DE students, and I interviewed many of them too. The student interviews and observations were conducted at the students’ homes (6 cases), at schools (31 cases), and via telephone (4 cases). Home tutors were interviewed in homes, teachers and administrators at schools, and technicians at schools and development institutes. Interviews were tape-recorded and then transcribed. DE lessons were conducted through telephone and radio, and I observed them
both from homes together with students (2 cases), and from schools and development institutes together with teachers (9 cases).

During the interviews, I used open questions like: "Please explain to me how you are studying" or "Describe your contacts with other students." The students showed me their material and allowed me to observe their participation in lessons. I was also shown around on the farm or school. Although I had a focus on collaboration and the use of technology, I tried to get a picture, as complete as possible, of the student's perception of what it means to be a DE student.

The students were presented to me by the DE schools, which means that I have not been able to choose whom to interview. The practical circumstances for the visits, like distance, road condition and parents’ willingness to co-operate, influenced the choice. I cannot exclude the risk that the sample is imbalanced.

In reporting the results, I let the students be “heard” through citations from interviews. I have given each one of the 41 students a code to indicate the category: S for School-based, R for Rural home-based, and O for Other home-based student. Teachers are marked Tr, Technicians Tn. Utterances from lessons are marked Ln. To this code, I have added a consecutive number.

Activity Theory as a framework for analysis

The results are analysed according to the Activity Theory (AT) framework (Engeström, 1987). AT can be used as a framework to study the complexity of human activity. Here, it is used to analyse relationships between the learner and the ICT tools, the peer learners and the whole environment. AT takes into account the context, the social interaction between humans, and the continuous development. It focuses on the role of tools and it regards the user as a person with his or her own will, acting deliberately with clear objects in mind (Nardi, 1996).

![Figure 1: The structure of human activity (Engeström, 1987, p. 78)](image)

Engeström (1987) uses Figure 1 to illustrate dynamic relations and mutual dependencies between components involved in human activity. (In such AT figures, lines denote relations, and corners or nodes denote components.) The subject is involved in an activity directed towards an object with a certain desired outcome. The object is not just a goal, it is something that the subject needs; a construct with a motivating force, imbedded in the culture. “The object determines the horizon of possible goals and actions” (Engeström et al., 2002, p. 215). The activity is influenced by the instruments used, the community that the subject belongs to, and the kind of collaboration going on in the community, guided through rules and division of labour (Engeström, 1987).

In my research here, I focus on the students and try to mirror their perception of what it means to be a DE student. I have, therefore, chosen to regard the student as the subject in my analysis. The object of the student's
activity is studies, and the desired outcome is to manage the studies in order to pass an exam. The instrument can be lessons, course material, a pedagogic method, and/or technology. The student belongs to a community of students, but here are also the teacher, the family and other important people.

Engeström and his co-researchers have described an intervention in a school, where AT was used as a framework for understanding the process as ICT was introduced (Engeström et al., 2002). In their analysis, they used a teacher's perspective. The teachers' object was in focus: "The general object of teachers' work is students—or more accurately, the relationship between students and the knowledge they are supposed to acquire" (Engeström et al., 2002, p. 215). They described how contradictions within the object were identified, and discussed potential effects, which they called 'expansive learning'.

There is often a contradiction within nodes or between nodes in an activity system. According to Engeström (1987; 2001), these contradictions can be problematic—but if they are handled in a constructive way, they can also invoke development, through expansive learning: "learning what is not yet there by means of actions of questioning, modelling, and experimentation (Engeström, 1987). Its core is the collaborative creation of new artefacts and patterns of practice." (Engeström et al., 2002, p. 216). In the analysis of my results, presented next, I try to identify the occurrences of contradictions and resulting expansive learning, especially collaborative learning.

**Results**

Distance education in Australia is mainly built on three components: individual work with printed material, teacher-directed "online" lessons, and physical meetings (camps, mini-schools). What they call "online" lessons are lessons mediated through radio or telephone. The rest of the time, the student is supposed to study individually, with a home tutor or supervisor as local support. The communication between students and their teacher is mainly mail-based, with “online” lessons about once a week per subject. Physical meetings are offered once a semester. These components will be described in more detail in the following text, based on interviews and observations, and illustrated by citations from the interviews.

**Individual work**

At the beginning of a semester, each student got a package of booklets and other material, plus a schedule. Every third week they were to send in tasks, which were corrected and commented on by the teacher, and returned to the student. This individual work took at least 80% of the students’ study time.

Together with the printed material, they also got video and audiotapes, as complements. In one case, a student described this as a kind of compensation for collaboration:

O13: Yes, in English there are always audiotapes. ... For instance, when you read a book, you don’t get different opinions on it. So they make a tape with some kids talking about what they thought about what they read.

In a mainstream school, there could be a group of, say, five school-based students taking the same course at a distance. They normally worked individually in a room at school; but they did not have to go there, and some of them chose to work at home. At school they had access to computers, but they were not always connected to the Internet. If there was a group, they might collaborate, but normally they worked individually most of the time and only asked each other for help now and then, and if the material gave them a group task.

S23: There are four of us doing the same subject. We are just helping each other with the reading task. Just going through it together. If we have any problem, we ask each other; and if no one can help, we ring our teacher.

When home-based students got to a point in the material where it said that they should co-operate with others, they were allowed to skip it.

R6: Once in Human Biology I should test my own pulse and breathing rate and I needed someone to do it. But I could do it myself. It is not that great [a] thing.
O33: Yes, in Year 10 we were supposed to do a big assignment, like a project, together and one of us lived far away. And the other, I don’t know where – a couple of hours away. We ended up sending things back and forth, so our teacher said not to worry, because we were too far away. ... Yes, we phoned a couple of times to try and sort it out but it was just ridiculous, especially as you had to do it within two weeks. Sending it there takes three days.

Each DE student needed a tutor and with home-based students it was normally the mother. In a few homes I visited, it was the father. It could also be a governess. School-based students had a local tutor or supervisor/coordinator. The main role for the tutor was to solve practical problems and help the student to keep on with the studies. Most students said that the tutor was very important for them.

O15: It would be difficult without a home tutor. If she didn’t tell me, I wouldn’t work all day.

S35 and S36: There is a teacher at the school. He is our coordinator. He can help us sometimes and look things up. Or we call the teacher. We first try to help each other, and then ask the coordinator, then the teacher.

Talking to home tutors, I noticed that they often felt that the authorities did not value their work. They were not paid for it, although they spent a lot of time with their students, especially with young students. The tutors described the situation as a triangle between three equally important parts: the student, the teacher, and the tutor.

“Online” lessons

All schools offered “online” lessons through phone or high-frequency (HF) radio. During a lesson, the teacher normally started by greeting each student, asking about his or her situation. If anyone had problems with the tasks of the week, the teacher explained and tried to get everybody along. After that, the teacher went through next week’s tasks.

Not all students took advantage of these lessons, for different reasons. Some thought they were not helped by them, some found it difficult to hear other students, depending on the vast uptake area.

R11: Radio lessons are available but I don’t use it so much. I have other activities, and my older sister can help me, and my parents. ... I don’t really like asking for help. I prefer to figure it out myself.

R14: The problem is that in primary school there are enough students to group them in regional areas ... But in high school you have the whole area. We can’t hear the whole class.

Normally, the teacher addressed one student at a time with a question. If a student had a question or comment, he or she could call out his or her name, and the teacher gave the word to this student. Only at rare occasions did I notice a shorter discussion among the students. My impression was that the lessons were very much controlled by the teacher and that collaboration was rare.

O31: They pretty much tell us what we need to know and say: Do this and we do it, otherwise we get in trouble next week.

Tr38: The telephone lessons are very teacher-centred.

However, teachers told me that they try to let the students discuss when suitable issues appear. Some of the teachers were experimenting with forum discussions, e.g., within Australian Studies. One example mentioned by a teacher (Tr38) was a group discussion about immigration. The students were given web sites to search for specific information. The groups were to summarise what they found and then read and comment on each other’s work. The first time when this teacher practised this mode, she had problems to activate the discussion. She then read about Salmon’s (2000) 5-step model, where the first step was to make sure the technology works for each individual student, and that everybody is motivated to participate. So she referred the students with technology problems to a local technician. She also started to e-mail individually to some students. This time, she managed to create a lively discussion and the students were happy. They found it easier to read what other students had written than to read from the initial source.
Students also witnessed that they appreciated listening and talking to peers.

O13: But sometimes, when you are on the radio and you ask the teacher something, they ask: Can anyone else answer that? ... the kids would explain it better because the teacher has other thinking. ...

S30: It is good because you can talk to them [other students] and say: 'You did this' and 'Was it hard?' 'Did you pass?'

O31: Yes, my biology class is really good. We joke about and bounce [ideas] off each other and stuff. It is good to have a conference because I have had a few one-to-one lessons and you just got the pressure on you. I prefer conference style. ... Well, it was just a bunch of blokes, from some school up there. We can chat on the same level. Pretty smart blokes.

The opportunity to talk about the work and to report what has been done and what has not been done works as a kind of group pressure.

O13: It’s just like helping along. And I think that with that help every week it really helps you to go along. Because otherwise you could be a little bit behind. You try to catch up so the other kids don’t know that you are behind. ... Yea, a good kind of peer pressure.

On a few occasions, an online "whiteboard" was used. Computers were used as communication tools, mediating not only the voices but also what was drawn or written on a "whiteboard" on the screen. In this way, the students could see what the teacher was talking about: a formula, a diagram or an equation. They could follow how it developed on the screen and interrupt the teacher if they did not understand. Also, the students could use the whiteboard to draw or write something. This implied a broader interaction between teacher and students than when only the voice was used. I could observe a strong engagement among four young students taking part in such an activity. They observed the screen attentively and took turns in answering the questions. During a group interview, two students gave the following description.

S35 and 36: Last year we had whiteboard lessons, so the teacher could draw and we could see. That’s good. They could draw diagrams and we could understand what they were talking about. ... Just while they are talking, say like a formula or something, like an equation. They are actually writing it out and you can see how it’s working, it’s in front of you. They tell you an equation and you can try it, how it is. And they can say immediately if it’s right. ... Yes, and we can add a picture or write ourselves.

During another group interview in connection with a phone-based “online” lesson, I asked: "What would happen if you had a call without the teacher?" The answer was:

Ln37: That would be cool! But we would never get any work done.

Most schools were experimenting with some kind of computer-based communication tool, mostly using synchronous mode. One technician described that the purpose is: "...for the students can get immediate feedback. The teacher can hold up a book and point ... There will be a camera at the teachers’ end, not the students’ end. That would cost too much.” (Tn16) Obviously, this is not primarily meant for student collaboration but for enhancing the student-teacher communication.

Physical meetings

Physical meetings are different forms of face-to-face meetings, normally occurring once a semester for each student. ‘Practicals’ are compulsory in physics, chemistry and the like. The rest is optional, but most students try to attend. For some students, the journey is too long to do this each semester.

R14: When we come down to camps like this, when teachers have really important issues like that ... then we spend some time on them and we do have discussions about them but probably not as much as in mainstream schools. I haven’t been to high school so I don’t know how much ... We certainly don’t tend to do that kind of things [discussions] with our peers.
Most students seemed to be very happy about the opportunities to meet peers and teachers at the face-to-face meetings. There were, however, some practical problems concerning long journeys and teachers having other classes.

Analysis

Applying Activity Theory

The structure of human activity (Engeström, 1987) can help us to understand what is going on here (cf. Figure 1). Considering the motives that students (subject) give to their studies, I deduce that the object of this activity is the completion of an education in order to get a job in the future (outcome). This is not very surprising, and could be valid also for most mainstream students. But among the DE students that I talked to, there is an additional component: to carry out the studies individually. These students are very proud of managing their studies by themselves, taking responsibility for how they use their time. This is especially valid for home-based students. The freedom is an integrated part in the way of life on the big farms.

Some people say you don’t see the real world [as a DE student]. You don’t view the pressure that will be on you when you go to a workplace. But I think that kids on home schooling would work better on a workplace than - this is just my opinion – kids that go to mainstream schools with other kids because those kids, sorry, most of the kids can only work with other kids around them.

I suppose the challenge. And I really like the sense of achievement. On the property [the farm], we have a really hard life. I enjoy every day. Getting a good mark. How can I get a better mark? Just the focus. I’m a very competitive sort of person.

I think we get a far more thorough education because we do it ourselves. Which means we can go much deeper and our minds are stretched more out. We spend a lot more time on it. We don’t have the attitude about school, more positive than in mainstream schools.

The best is that you don’t have someone hanging over you all the time. It’s all up to you. Everything you do is your fault.

The most important rule is that the students have to keep the deadlines. As long as they do so, they get their marks and the teacher does not complain. The family has the highest priority in their community, including the tutor/supervisor, with the teacher as the second. For most students whom I met, peer students seem to be less important when it comes to studying. They can be friends to meet with at camps, but not a person to learn from or together with.

The division of labour is rather clear: The student works with the printed material and sends in the completed tasks. The teacher sends the material and returns tasks with marks and feedback. In most “online” lessons, the teacher checks that the students work on, in accordance with their schedule. The main role for the tutor is to explain difficult parts, and to push the student to do the work. The instrument for this activity consists of printed and electronic material as well as pedagogic methods and communication tools.

In conclusion, in most cases that I have observed, the situation seems to be very similar to the correspondence education given while paper mail was the only way of communication. The “online” lessons, although most students and teachers regard them as important, have not changed the pattern of the activity system. They have just made the communication faster between teacher and student. Is this a static situation or are there any signs of contradictions that could lead to development?

Contradictions introducing expansive learning

I have observed several contradictions and also examples of development that I conclude are results from these contradictions. In the following text, I describe these contradictions and any resulting development in six steps.

Some students express an interest in listening to and talking to other students. The opportunity to talk about the work and to report what has been done and what has not been done works as a kind of group pressure. Some of the students express a wish to collaborate with other students.
O33: I think it makes a big difference [to collaborate]. Because with collaborative tasks you get two different people’s view. I think it’s better to have more people working in a group. ... different views on the issue, rather than just one view.

R14: We don’t have that much interaction as in schoolwork. This is a drawback for DE that you don’t tend to discuss and work with other students.

We see here that the standpoint, that a DE student only studies as an individual, is challenged. There is something to learn from other students. This is a contradiction within the object, which can expand the students' view on learning and on how to study. I list this (Step1) and the following steps in Table 1.

There are some practical constraints concerning the telephone and HF radio communication.

R26: We can’t have the Internet or email. We have phone on a radio line. We will get a satellite soon.

R12: Well, it very much depends on for how long we run the generator. That usually means 4 hours in the morning and 4 hours in the night. But unfortunately, on our property the connection is really, really slow. But we have signed on for a satellite two-way connection via Telstra. The government pays ...

This points out a contradiction (Step 2) between object and instrument: If the students are to learn together, the communication between students, not only between student and teacher, has to work well. At many remote farms, the equipment is too weak to make computer communication possible. Investments in satellite connection are on their way, but it seems impossible that all remote areas and farms will have effective computer communication in a near future.

Another contradiction lies in the fact that teachers do not offer learning situations where collaboration is promoted, a contradiction between object and instrument (Step 3). The instruction-based teaching mode seems to dominate, but I have seen signs of a re-orientation. Some of the teachers were introducing forum discussions and electronic whiteboards.

We can notice that this expansive-learning activity met some technical problems. Not only has the hardware and software to be there; students also need to know how to use it. That demands some local support. This introduces a new role in the community: ICT support. A contradiction within the object (learning does not have to be individual) introduces a contradiction between object and instrument (technology relevant for collaboration is not available) (Step 2), and, in turn, between instrument and division of labour (technology can not be used without local support) (Step 4). The rules are also challenged by the new object (Step 5). Students might now talk to each other during the “online” lessons, without any interference from the teacher. They might even get each other's e-mail addresses or phone numbers, which have not been distributed before. The division of labour between teacher and student might also change as students take advantage of the possibility to learn from each other (Step 6).

Table 1 gives an overview over the development that could be introduced by the different contradictions. These steps are not necessarily consecutive. I have not had the opportunity to follow the development over time, but I have observed instances of different positions in the development.

<table>
<thead>
<tr>
<th>Step</th>
<th>Contradiction</th>
<th>Position in Figure 1</th>
<th>Potential expansive-learning activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Individual learning, not collaboration</td>
<td>Within object</td>
<td>Expansion of students’ object</td>
</tr>
<tr>
<td>2</td>
<td>Irrelevant communication technology</td>
<td>Between object and instrument</td>
<td>Demands for better infrastructure</td>
</tr>
<tr>
<td>3</td>
<td>Teachers do not create collaborative learning opportunities</td>
<td>Between object and instrument</td>
<td>Introduction of new pedagogy</td>
</tr>
<tr>
<td>4</td>
<td>No ICT support available</td>
<td>Between instrument and division of labour</td>
<td>Local ICT support is introduced</td>
</tr>
<tr>
<td>5</td>
<td>Students are not to talk to each other</td>
<td>Between object and rules</td>
<td>Students may discuss</td>
</tr>
</tbody>
</table>
Students are taught by teachers

Between object and
division of labour

Students can learn from
each other

Development is initiated by contradictions within nodes and between nodes in the activity system. Looking outside, we also find contradictions. When students compare their situation with what is going on in mainstream schooling, they find differences that might present new demands, e.g., the use of modern ICT. Teachers and technicians show interest in developing and testing new technology and pedagogy for collaboration. In many DE schools, there is an intense development going on toward more use of ICT. This development is going in different directions with the emphasis on better, mainly synchronous communication tools, and mainly the communication between teacher and student. There are, however, examples of teachers and tool development focusing on the collaboration between students.

As shown in the beginning of this paper, there is a pressure from governmental principles and guidelines to introduce collaboration in education, both to foster flexibility and openness, and to enhance learning outcomes. These guidelines apply also to distance education.

Discussion

The traditional way of studying at a distance was by correspondence. The students got printed material to study individually with tasks to complete and submit to the teacher, who corrected and sent the result back. There was no synchronous communication between teacher, and student and no communication at all between students, except, maybe, around examinations. Nowadays, synchronous communication has been added, through “online” lessons by radio and telephone, but the tradition of individual studies seems to continue.

Many students value the training in individual learning and hold that this is a perfect preparation for university studies and work. They seem to be proud of being self-sufficient and self-motivated. Some students, however, find this problematic and need to be pushed by parents and supervisors. Some students miss the possibility to study together with other students; when they get the opportunity, they find it very engaging and rewarding.

The purpose of “online” lessons seems to be to offer a faster feedback to students, and this is something that they value. Reasons to connect several students at the same time may be economy, administration, and to ease the burden on the teacher by offering the possibility to give instructions to many students at the same time. Some students argue that they learn even better from explanations given to them by other students than by teachers. This reveals a series of contradictions. A contradiction like this can be solved, according to Engeström (1987), by expansive learning.

My interpretation is that the contradictions have occurred because the traditional view on DE students as individual learners has been provoked by the possibilities given by technology and the wish from the students to collaborate during “online” lessons. The expansive-learning activity would then be to redefine DE students as learning also by collaboration. However, for change to occur, also teachers have to adapt their pedagogy to the new view on learning, the communication technology has to be upgraded, support introduced, and rules and roles adapted to the new situation.

Why is this development so slow in Australia? In many other countries, there is an extensive use of collaborative learning through ICT tools in DE. This probably has two explanations. First, the infrastructure is not there and because of the vast country it will be extremely expensive to provide all farms with good computer communication. Second, the strong culture from old correspondence education, which has worked well for many decades, stays in mind of both students and teachers.

Conclusions

A broad picture of the DE culture in Australia shows: Vast distances, students on remote farms, importance of independence and individual work, a century of paper-mail correspondence tradition; and quite recently, the introduction of ICT. Here, collaborative learning by means of ICT has been slow to start, although there are some forces towards collaborative learning in different forms within DE in Australia. Starting from the top: Governmental principles and guidelines state that collaborative learning should be an integrated part in education. Teachers and technicians are inspired by new technology to develop their pedagogic instruments and
tools. Students appreciate to collaborate with peers if and when they get a chance. However, the obstacles are enormous, especially for remote home-based students without electronic communication. The expensive infrastructure and the correspondence traditions are delaying change. Even though the obstacles are big and collaborative learning is rare within Australian DE today, expansive learning initiated by new technology, government, engaged teachers, and a strong interest from many students have started a dynamic development towards more collaborative learning.

The experiences in Australia, shown in this paper, can be of great value for countries with comparable conditions. The Swedish government is considering DE for young students in small towns without resources to offer all courses (Fåhraeus & Jonsson, 2002). Many other countries are in similar situations. Different cultures might, however, cause trouble if you try to copy solutions from one country to the other. It would, therefore, be interesting to make analogous studies in some other countries with different education cultures.

Acknowledgements

Thanks go to all students, parents, teachers, administrators and technicians who let me interview and observe them. I especially want to mention Peter Barker, WA, Bob Rasmussen, QLD, Ian McKay, QLD, and Chris Dolan, SA, who welcomed me to their schools and helped me to get in contact with interviewees. I am also indebted to Hugh Clift, who made it possible for me to travel to remote students and schools in WA.

References


Online Education, Learning Management Systems, Global E-Learning in a Scandinavian Perspective
(Book Review)

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Textbook Details:
Online Education, Learning Management Systems, Global E-Learning in a Scandinavian Perspective
2003 1st Edition
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NKI Forlaget, Hans Burumsvæl 30, N-1357 Bekkestua, Norway http://www.nkiforlaget.no/
ISBN 82 562 5B94 2 (Printed Version)
ISBN 82 562 604B 3 (PDF version)
ISBN 82 562 6049 1 (Microsoft Reader Version)

Electronic Layout Tools:
Reasonably well-labelled section headings accompany the PDF version, making use of the navigation pane, bookmark, and thumbnail facilities. This assists initial overviewing and easy return to content sections of interest. Better distinction for the position of numbered parts would improve the facility.

Presentation:
Coming to terms with a 337-page e-book in PDF format is an interesting experience for a reviewer. There are advantages to being able to assess the contents continually while the book is being read, but it loses the feel of a 'flick-through' overview. No doubt many students and tutors have already addressed the merits and difficulties of e-books within their courses, but without a handheld device, it remains hard to make a mental distinction between a long consultation document, and a pleasurable read of a new work in the field.

Yet, learning about other approaches to online education is always a rewarding experience, and in a field that relies on electronic delivery for its business, this is an interesting, and not yet common enough, development. Offering practical solutions regarding its own media type is significant for a work that describes perspective and experience within a field that has developed to allow its participants to take advantage of flexible forms of communication and delivery. So, it is impressive that the publishers have made the effort to provide multiple formats of the work, and that ISBN numbers for printed, PDF and Microsoft Reader versions are available. This should allow the most appropriate format for purpose to be selected, based on the functionality of each technology. Those requiring a print format are able to obtain a hardcopy version, avoiding lengthy printouts, while the pdf version is more appropriate for electronic working or distribution. The book is also distinctive since the author has received financial support from the Norwegian Non-fiction Literature Fund.

So as a book that offers an European 'regional' perspective (Scandinavian), with comment from a different international area, by way of a Canadian Postscript, I approached this work with anticipation.

Rationale and International Focus:
The work is an ambitious one. Its target is to open gateways between Nordic, European and international educators and the integration of theory and practice. In this respect, the book itself merely forms a starting point, intended to reflect the first steps of a learning process leading to wider collaboration, in the same way a single resource might present the first step to achieving learning outcomes within a blended media course. To emphasise this approach, the book is richly supported by contextual material, including a multimedia interview (http://www.studymentor.com) with the author about his background for writing the book. There, the author
provides information concerning his story of this book, its context (of long and outstanding international experience in the field), and more. An opening space for international online conferences is also available in support of collaboration.

Yet the theme of ‘export of education’ is clearly at the front of the authors mind, when he presents his perspective from the Scandinavian point of view. This offers interesting contrasts throughout. The international reader is required to approach topics from a less familiar perspective, which raises its own set of questions as to what we do and why we do it. Where for the Scandinavian reader, the aim is to demonstrate the wealth of Scandinavian achievement with technologies related to learning and to demonstrate how, despite this wealth of experience, ‘export of learning’ is not occurring. Instead, it is portrayed as more in the situation of being infiltrated or in some areas, over-run, by those brought in to assist its further development with the original intention of assisting to cover specific areas of weakness. However, readers from all cultures are more likely to identify with the recurring background themes of ‘cost effectiveness’ and ‘sustainability’.

The Canadian perspective extends specific themes within the book to consider economic growth strategies offered by online learning, and how language considerations of the home country may prove advantageous or otherwise for international marketing of online courses. Pertinent issues are raised that should trigger significant questions for all countries with an interest in better serving their students through further development of online courses. In particular, US and Canadian educational arrangements are compared, to illustrate what courses are able to offer, and considered in the context of their home country's political management structure for education. This discussion, when held next to the main work, becomes a good basis for considering what lessons, or understanding of educational constraints from each country's circumstances, may be useful in terms of transfer of experience from one national context to another. It is significant in outlining why barriers and experiences may not be directly transferable, and in which areas to look to improve a single country's advantage in developing online learning.

Australia is also drawn into the comparison through a ‘Comparative Study of Online Education Support Systems in Scandinavian and Australian Universities’, within the context of a wider presentation of Learning Management Systems and their use across the Nordic countries. In this, the author arrives at the conclusion that there seems to be a general lack of integration between these systems in all three countries, as well as little focus on standards specifications. In addition, Norway and Sweden value the importance of nationally developed LMS systems and student management systems; where there seemed to be much more national co-ordination and governmental coercion concerning the choice of student management systems, than in Australia. And again, through the theme of economic policy, the concept of ‘export of education’ reappears. This is put forward as the most striking difference between the three countries, where Australia considers [online] education as an important export industry, but in contrast, Norway and Sweden, do not seem to hold any interest in raising this as an issue for public discussion.

Approach:

Inclusion of these perspectives allows the book to be approached in many ways. Readers may find it helpful to be flexible about the parts they read first, in order to gain the most from the variety of material on offer. For example, the Forewords, Preface and Postscripts are significant in the way they enhance and underpin the gateway approach, and set the perspective and context for the four main sections. Readers with a general interest in collaborations within Online Learning, or with international perspectives on the field, may find it helpful to approach the book from this angle first. However, those readers with more specialist requirements may wish to delve straight into the meat of specific sections instead.

Throughout the book, the author combines interesting theoretical concepts and sound empirical data with anecdotes, to illuminate distance and online education from different levels and perspectives of everyday practice. Despite the data being somewhat older, the observations remain valuable. It is worth bearing this in mind when some of the findings or anecdotes may seem like lessons already learned. In fact, the precise role of the book is succinctly described by Erwin Wagner, in his foreword, when he notes that the ‘...book summarises what leading researchers have contributed to the research and what many students and many online teachers have contributed to our present knowledge on how to resolve practical problems. In fact this book very effectively helps to create and structure this knowledge itself.’
The main material is presented in four themed parts, comprising a mixture of articles and anecdotes, or case studies, to illustrate specific perspectives.

Part 1 provides an overview of online education, teaching & learning through a descriptive glossary, three articles and three anecdotes, which are presented from the viewpoint of one student, one tutor, and a global primary school. The first article introduces the theory of co-operative freedom (derived from distance education) applying it to online education, and argues that online education can foster both freedom for the individual and group cooperation. The second article presents seven distinct features of online teaching, subsequently introducing the characteristics of online learners and their special needs from the perspective of distance education, adult education, and online education. The third article presents experiences with teaching techniques found in the literature, recommended by some 150 online teachers interviewed about their experiences with teaching techniques. The analysis of the interviews showed that discussion groups, project groups, lectures, correspondence studies, and use of databases were the most used online teaching techniques.

Part 2 offers two articles and two anecdotes. The first article discusses global issues surrounding international web-based education and makes strategic recommendations for decision makers. The research presented was conducted within the Cisaer project, supported by the European Leonardo da Vinci program. The results and discussions are based on literature reviews, catalogue entries submitted by 130 institutions in 26 countries, and 72 interviews with key persons at these institutions, obtained over a one-year period during 1998-9. The second article presents an analysis of LMS systems, conducted in 2001-2 for the European Web-edu project. Data was collected from interviews with 113 European experts, from 17 countries, who were usually the systems managers in the institutions. Interview analyses revealed as many as 52 different commercial and 35 self-developed LMS systems. The anecdote ‘Online Education Obituaries’ argues that successful online education should be sustainable, noting that ‘It is therefore of great concern that much of the online education that has been offered so far has been transient, unsuccessful and far from sustainable’. The anecdote explores the reasons behind this, questioning how sustainability may be built into future initiatives, yet acknowledging unsustainable attempts in terms of their value to individuals, institutions, and society. In contrast, ‘Fronter’ describes the story behind a dawning Norwegian LMS success.

Part 3 looks at the Nordic Scene represented by Denmark, Finland, Iceland, Norway, and Sweden. Two articles present perspectives on Learning Management Systems (LMS) in the Nordic Countries and A Comparative Study of Online Education Support Systems in Scandinavian and Australian Universities. The first article presents the results from an analysis of online education and LMS systems based on a literature review and in-depth interviews with 20 selected Nordic training managers in 2001. The analysis comprises a broad range of institutions from primary education, secondary education, higher education, distance education, and corporate training. The comparative study discusses systems comprising content creation tools and systems for learning management, student management, and accounting. More use of anecdotes is made in support of this area, including a personal account of Online Learning in Denmark, a provocative statement on Swedish Challenges of the move towards Online Education, a discussion on Nordic Virtual Universities, and Two Decades of Online Sustainability as presented by NKI Fjernundervisning, or the NKI Internet College.

Part 4 presents one article, and one anecdote, on potential improvements and accessibility of the systems that are used to offer online education. The article presents an analysis of the answers the Web-edu project team members received when they asked 113 experts in 17 European countries what features they would like to see included in their future LMS systems. The analysis indicates thirteen key needs and concerns drawn out from this study. A personal view of the future of online learning is presented which makes a qualified attempt to envisage some of the developments towards 2010, based on the history of online education and the trends that have been elucidated throughout this book.

Global-Individual Perspectives

The work succeeds in presenting localised perspectives of an expanding field, and aligning these with different international experiences. Where research can span several years, but the field is fast-moving, anecdotes have allowed the work to retain the essence of individual experience, and to keep the focus on the growth and needs of all of the individuals involved in creating and participating in the learning experience online. As needs and
commonality of purpose is one basis on which communities are formed, the author has been consistent in presenting his extensive experience in a way that supports his ambition of the work as a gateway. Whether it succeeds in this is, of course, a more complex question, but it should not be a wasted read. There is enough here for each person to find something of value, independent of their focus and background, even if it is not what was expected at the start.
Distance Learning and University Effectiveness: Changing Educational Paradigms for Online learning
(Book Review)

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Textbook Details:
Distance Learning and University Effectiveness: Changing Educational Paradigms for Online learning
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16 chapters

Distance Learning and University Effectiveness: Changing Educational Paradigms for Online learning challenges the university administrators and faculty by making a case that new technological capabilities necessitate the pedagogical, research, and administrative changes in distance education. It engages the readers in the discussion that the existing pedagogies, reward systems, organizational structures, procedures and policies in higher education are not supporting today’s distance education in the form of online learning. Furthermore, the book proposes a need for change in traditional and conventional face-to-face methods of education to take advantage of technologies used for distance education. Overall, the book intends to support the premise that while technology is one of the transformational causes for colleges and universities, it is also one of the primary enablers of the needed changes.

The chapter authors, representing a broad spectrum of international expertise, present their perspectives on the idea that new and innovative educational paradigms and learning models are needed for online learning. While the majority of the chapter authors have backgrounds and experiences in information systems, information technology, information management, and business and public administration, there are some who extensively work as educators and instructional designers. Thus, even though the stronger focus of the book is on planning, developing, organizing and controlling the quality of distance education programs, pedagogical changes and challenges are also discussed. Using several examples of their own distance education programs, the chapter authors provide both conceptual and the practical points for consideration. In an attempt to provide coverage of instructional, structural and organizational issues, the editors also organize the book into three sections. The first section focuses on pedagogical changes, while the second and third sections concentrate on structural and organizational issues. This framework positions the chapters of the book so that they form one organized structure, enabling better understanding of the interconnections between pedagogical and organizational issues. The following is a brief section-by-section review of the book.

Section I sets the scene by discussing strategies and paradigms for distance education. The section consists of four chapters. The opening chapter brings reasons and research data to support the importance of improving the quality of education in online learning. It contends that given tools and technologies available, if designed properly, distance education courses can be more effective than face-to-face courses. However, the chapter concludes, the increase in the quality of distance learning is dependent on the faculty and their commitment to excellence in teaching and learning. In the future, the chapter adds, the institutions of higher education will be forced to re-evaluate the quality of teaching as they become more visible to the public, to legislators, and to prospective student. The second chapter of Section I builds on this appealing argument of effective distance education by proposing application of a set of instructional design principles. The author of this chapter puts forward a six-level design model that she believes to promote congruency and consistency among different
components of distance education programs at the institutional level. Using a set of procedures and guiding questions for each level of design, together with a description of a sample program, the chapter is rich in offering practical guidance within the proposed conceptual framework for planners of distance education programs at institutions of higher education.

The strong emphasis on the role of instructors in promoting the quality of distance learning and the importance of their appropriate use of the communication tools and technologies set the stage for the following chapter on e-modulating in higher education. Chapter 3 introduces the concept of e-modulating to capture the wide variety of roles and skills that online instructors need to have. It begins by identifying a list of competencies and skills for e-modulators and continues with providing practical and step-by-step suggestions for recruiting and training them. The chapter brings the issue to a close by providing an exemplar and examining the services and costs of such training and staff development programs for colleges and universities. At the end of this chapter, the reader, once again, is reminded of the fundamental role of interaction in online learning and the need for successful and productive e-modulators.

Section 1 concludes with a chapter discussing community-based distributed learning. As a concluding chapter, chapter 4 serves as an interesting complement to section 1 in that the debates between globalization and anti-globalization of education are examined. Basing their arguments on a middle ground and on the incorporation of the concept of community-based learning within the idea of globalization of education, the authors of the chapter defend a very interesting viewpoint. After analyzing the issue of how quality in technology enhances global education, the chapter authors suggest that educators and educational decision makers should build respectful partnerships with communities in an attempt to create a global learning environment, incorporating local knowledge and culturally relevant learning experiences. Two pilot programs are also presented as evidence to show how strategic partnerships may be used in the design and delivery of such programs.

Section II focuses on the instruction, course development and quality issues in distance education. Seven chapters in this section discuss various instructional issues from course planning, organization and instructional strategies to student satisfaction and challenges surrounding assessment, learning styles and cultural issues. The section opens with Chapter 5, which provides practical guidelines and discussion on the development of online courses. The chapter is built on the idea that while technology for course delivery will change, the effective delivery of content remains dependent upon appropriate instructional design techniques. The chapter authors are persuasive as they propose applying nine principles of Web-based design to help course developers overcome the challenges of creating student-centered learning environments. Given many visual examples and easy-to-apply practical and step-by-step guidelines, Chapter 5 is a highlight of section II.

Following Chapter 5 is Chapter 6, which makes a similar argument but from a different perspective. Chapter 6 adapts the systems theory, as a framework to analyze elements of distance education and to propose a model for designing and developing distance education programs. Using components of an organization as a system namely input, process, output and outcome the chapter encourages developers and planners to use the proposed Educational Process Model to rethink the entire process of developing distance education programs. Chapter 7 shifts the reader’s attention from the design and development of the distance education system to market driven factors that influence the acceptance of distance education. On the basis of the analysis of the results of a survey administered to a large group of MBA distance education programs, the chapter generates five constructs that correlate with student satisfaction. Using these factors as a guide, the chapter discusses some operational and administrative issues.

Chapters 8, 9 and 11 take a more specific approach and focus particularly on assessment of student learning and student cultural differences. Chapter 8 begins this discussion by suggesting an alignment between course learning objectives, instruction, and assessment and by examining issues related to effects of the instructor’s pedagogical beliefs and perspectives, including course design on online assessment. Establishing the needs for engaging students with the materials and course content in a meaningful way in an online course, the chapter suggests a number of assessment strategies. Chapter 9 compares assessment strategies in two sections of a graduate programming course, where one was on campus and the other online to identify differences in perceived test performance. In addition to confirming some of the previously raised issues, the chapter adds one more area of concern for the distance education developers and instructors.

If one skips Chapter 10, which does not directly relate to assessment of student learning and is primarily focused on modular Web-based teaching, Chapter 11 concentrate on students learning. This chapter makes an interesting, yet very important argument on the impact of cultural diversity on group interactions through technology. The chapter captures the reader’s attention as soon as it begins presenting cases and scenarios that highlight some
cultural differences. Even though the discussion challenges the distance education administrators and developers by raising important questions, it does not provide practical guidance. Examples are also limited in scope and implications.

Chapter 10, as indicated above, presents modular Web-based learning and teaching and also presents the teaching model as a new and innovative design and delivery method for online learning. Given that the chapter is more in line with general design and development issues, it is not clear why it is grouped with chapters that focus on assessment of student learning. In spite of the many figures and examples presented, including a new and innovative approach for e-learning materials, Chapter 10 is somewhat abstract and difficult to follow.

Section III presents issues and strategies for building an organization for successful distance learning programs. Five chapters in this section discuss the ways in which online programs can become cost effective. The first chapter in this section, Chapter 12, proposes the idea of using the strength of the Internet for supplementing and adding value to traditional face-to-face classes rather than replacing them. To further support this argument, the chapter introduces the concept of “e-store” to promote faculty created materials and to provide new ways of packing and delivering education that have greater potential for rewarding the faculty developer. The following chapters in this section, Chapters 13, 14 and 15, examine ways in which institutions can maximize their return on investment for distance education offerings. Chapters 13 and 14 are very intriguing for distance education planners in the time of reduced budgets. During the time that distance learning has proven to be no cheaper than traditional education, and the likelihood that it is not going to get any cheaper, these chapters provide very interesting and appealing implementation and organizational models to make online learning cost effective. The next chapter in this section, Chapter 15, proposes the idea of an inter-university education network. Using a case study, the chapter explains the cost- and market-oriented advantages of co-operating between universities. Building on the idea of a modular approach to designing and delivering instructional products and high costs for development and operation of such high quality trainings, the chapter provides case evidence in support of market advantages of co-operation between universities. The chapter also discusses some problems and questions about managing open education networks in a co-operative environment. The final chapter, Chapter 16, concludes the discussion by providing research data to shows that students perceive a face-to-face course supported by a Web site to be more useful in enhancing their academic performance. It makes a case that a Web assisted course which could blend the best of both face-to-face and online learning is an ideal way to enrich the student learning experiences.

In sum, the book is impressive in many respects. It aims to offer new and innovative ideas on the structure and organization of distance education in form of online learning. Although the book does not cover all issues related to online learning, it contains a wealth of useful ideas and approaches. The many examples, cases, guiding questions, figures and tables provide excellent practical ideas and guidelines for planners and developers of online learning programs. The insights presented in the book also reflect both richness and diversity.

The book is not an introductory book. It also cannot be described as 'everything you wanted to know about e-learning', but it might help in answering some of the questions that should be asked about e-learning. For readers who are relatively new to the field of e-learning and who are looking for a straightforward introduction, this book is probably not the best choice. But it will no doubt be a great source of inspiration and innovation for those who are actively involved in the design, development, implementation and organization of Web-based distance education. The size of the book and the concepts presented make it difficult to review, however, I have read most of its chapters with interest and pleasure.
Global Peace through the Global University System
(Book Review)

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Textbook Details:
Global Peace through the Global University System
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517 Pages

This book is an interesting collection of writings concerning the development of international partnerships and the pursuit of global peace. The book is divided into four basic parts that describe the international development of global peace by utilizing the concept of Global University. The precept here is to understand that the authors of the various topics believe that peace is obtainable in a number ways but the education of the world and peace must be approached in a global fashion.

Part I: Greetings and Visions: This part of the text deals with such topics as "threats and opportunities" to "e-learning" and the various relationships to global peace. Just about every factor possible that could affect peace and the concept of globalization is discussed in the section by many world renowned authors. Some are articles and some are speeches. The coverage is thorough and broad.

Part II: Intercultural Studies and Peace Education: This section discusses topics ranging from "creating the global University System" to "nurturing the peace culture." In this section there is considerable discussion on the establishment of the Global University System (GUS) and the technological requirements for such an organization. The use of internet courses and other means of electronic education are presented in length.

Part III: Global E-Learning and E-Healthcare: This portion of the writings is heavily involved with the electronic and health connections associated with GUS. The title for this section is a little misleading in that the connection to GUS and health is actually more social than health. The health topic is more societal and the evolutionary relationship of man to global corporations. The concept expressed here is that "the increased productivity of an individual person - 'an enterprise of one:' is the driving force for knowledge globally."

Part IV: Global Collaboration: This section of the book is devoted to a broad and in-depth look at all that could or should be involved in the international education community and the relationships that exist in technology worldwide. This is a very interesting portion of the writings because it approaches the "reality" part of learning and everything that is associated with the delivery and acceptance of knowledge. Technological topics such as broadband satellite communication are among the topics discussed.

In summary, this book is an interesting collection of writings and speeches that rise to a very high level of discussion on some very broad topics concerning a Global University System and the potential impact that it may have on the world. As in all collections some of the topics are more interesting than others depending on the reader's interests but one is sure to find many that are intriguing and thought provoking.