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 The articles should be original, unpublished, and not in consideration for publication elsewhere at the time of submission to *Educational Technology & Society* and three months thereafter.

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Book review(s)

Muirhead, B. (2007). Integrating Creativity into Online University Classes. *Educational Technology & Society*, 10 (1), 1-13.

Integrating Creativity into Online University Classes

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Discussion Schedule:
Discussion: September 7-14, 2006
Summing-up: September 15-16, 2006

Pre-Discussion Paper

Introduction

The author will provide a concise discussion on creativity, defining the term, sharing theoretical background information and offering insights into promoting creativity in online university classes. Emphasis will be placed on relevant ways to integrate creativity into instructional activities across the academic disciplines.

Defining Creativity

The term creativity often will focus on individuals producing novel or original works. Sawyer (2006) believes "…that all creativity includes elements of imitation and tradition. There is no such thing as a completely novel work. To explain creativity, we have to examine the balance of imitation and innovation, and the key role played by convention and tradition" (pp. 24-25). Sawyer's argues against placing a too much emphasis on being novel. Yet, educational psychologists often recognize the novel element in their definitions. Sternberg (2005) relates that "Creativity refers to the skills and attitudes needed for generating ideas and products that are (a) relatively novel, (b) high in quality, and (c) appropriate to the task at hand" (para#6).

The term creativity can be an illusive term to define because writers do not want to undermine or diminish the positive aspects that are often associated with the word. A basic definition of creativity is the ability to produce novel (original/unexpected) work that is high in quality and is appropriate (useful). A survey of definitions of creativity highlights the intriguing qualities of this term. Harris (1998) provides one of the best descriptions of creativity:

- **An Ability**: A simple definition is that creativity is the ability to imagine or invent something new.
- **An Attitude:** Creativity is also an attitude: the attitude to accept change and newness, a willingness to play with ideas and possibilities, a flexibility of outlook, the habit of enjoying the good, while looking for ways to improve it.
- **A Process**: Creative people work hard and continually to improve ideas and solutions, by making gradual alternations and refinements to their works (para 2, 4 & 5).

The description highlights the multidimensional nature of creativity while stressing that individuals must realize that it involves hard work and a flexible mental attitude. There seems to be some misconception about the need for hard work but it is affirmed by today's writers. Howe (1999) has conducted a biographical analysis of people who were considered in the category of being a genius (e.g. Einstein) due to their exceptional work. A detailed historical examination of their lives has shown that most were characterized by having a tremendous work ethic. This enabled them to have the diligence and patience to use problem solving techniques to reach brilliant solutions with their ideas

Theoretical/Conceptual Framework

There is a degree of mystery associated with the subject of creativity that challenges educators to continue investigating how individuals translate their imaginations and ideas into innovative projects. Unfortunately, educators have often been influenced by pragmatic approaches that place a strong emphasis on practice with a lower priority on theory. Edward De Bono's work on lateral thinking has been a commercial success by promoting two types of creativity strategies: Positive-Minus-Interesting (PMI) and thinking hats. Von Oech's focus is to encourage people to adopt a variety of roles: explorer, artist, judge and warrior. Practical approaches have a certain appeal due to their simplicity but they often lack scientific testing and validity (Sternberg et al, 2005).

Researchers argue that a comprehensive assessment of creativity is a complex task because it involves considering the field of study and temporal context of work. It includes looking at a diversity of variables such as cognitive processes, personality, motivation and the individuals background (Sternberg et al, 2005). Therefore, a major challenge for educators is how to effectively offer relevant instructional activities. Teachers can provide valuable knowledge and advice to their students that will promote enduring creativity in their lives. For instance, creative people must be willing to overcome resistance to their ideas and plans. Sternberg (2003) relates that "I have often wondered why so many people start off their careers doing creative work and then vanish from the radar screen. I think I know at least one reason why: Sooner or later, they decide that being creative is not worth the resistance and punishment" (p. 113). Teachers can prepare students to face and overcome obstacles by relating personal narratives on when they encountered people who were not supportive and reacted negatively to their best ideas. Instructors should have students read materials (e.g. articles and instructor lectures) that will enhance their awareness of issues associated with the creative process. Students should learn that obstacles can appear in different forms such as external issues (e.g. fearing the opinions of others) or reflect internal battles with performance anxieties. Teachers can use vigorous group discussions that mentally equip students to handle adversity during their creative projects (Sternberg, 2003).

The social-personality and social-cognitive approaches have focused on three major sources of creativity: personality variables, motivational variables and sociocultural environment. Carl Rogers and Abraham Maslow emphasize self-actualization connected with self-acceptance and a supportive environment. Researchers have identified numerous creative individuals who had weak people skills and struggled to cope with their daily routines. The 1950s-1970s saw psychologists striving to develop a test to measure creative potential similar to the modern IQ tests. Various personality tests were utilized to measure creativity but they tended to reveal information on social achievement. Creativity research during this era did affirm that creativity was related to individuals having a strong work ethic, dedicated to completing tasks, being motivated and have a good working knowledge of their job. Yet, the researchers were not able to develop a personality test that could effectively identify exceptional talent in children or identify particular personality traits that were characteristic of creative people (Sawyer, 2006).

During the 1970s, cognitive psychologists began to emerge with new approaches for examining creativity. Researchers focused on studying mental processes instead of the creative personalities. Cognitive studies led to undermining the idealists theory that stressed once a creative concept was produced, it is not essential to implement the idea. In contrast, action theory advocates the execution of ideas as being a key part of the creative process. Therefore, creativity happens over time and while the individual is working on using their ideas in a project (e.g. artwork). The creative process has four primary stages: preparation, incubation, insight, and verification (Sawyer, 2006).

The 1990s saw researchers seeing the need to account for the multidimensional nature of creativity. Lubart and Sternberg's (1995) investment theory argues that certain people will investigate unknown or unpopular ideas if they reflect potential value. These individuals will study and promote their new ideas even when others fail to support them. In fact, they have the confidence and determination to continue their investigation of new ideas until they gain more favor in the public arena. Then, they will move on to another unpopular idea. This is called a "buy low and sell high" (Sternberg et al, 2005, p. 361) strategy and it highlights how a certain category of ideas can represent a unique but welcome challenge for some people.

Cognitive psychologists have recognized an important paradox found in creative accomplishments involving both personal playfulness and discipline. Creative individuals work very hard and continue their work with a level of persistence which is rarely matched by others. They often possess playful attitudes which help them deal with ideas with an abandonment and imagination. It provides a definite break from seriously pondering complex ideas and can foster a receptive mental outlook for considering novel concepts or ideas. Online educators should include activities such as interactive puzzles that are more playful and represent a change in daily learning routines and stimulate creativity (Csikszentmihalyi, 1996).

Creativity researchers are taking a variety of new theoretical approaches such as Sawyer (2006) who is an advocate of the emergence metaphor. This reflects an effort to provide a more dynamic picture of the creative process. It offers a practical way to interpret phenomenological information during the actual process. Secondly, it allows for more comprehensive and multidimensional perspective toward creativity. Moran (2002, para 31) relates that the metaphor "…makes explicit a prospective role for time, and emphasizes works-in-progress and iterations, which Gruber purported to be critical to any study of creative process...it changes our focus from entities—creative works and people—to process, not in terms of techniques or steps, but as a continuous transformation: of finding not edges but rather gaps within. Finally, it increases our sensitivity to interactions of properties, not just the properties themselves. In sum, the new metaphor orients our attention to different aspects of creativity, or ways of thinking about creativity, than does the boundary metaphor."

Online Instructional Approaches

Teaching creativity and higher order thinking skills transcends any specific formula. The author advocates integrating creativity objectives into the curriculum which offers a subject oriented basis for reflective activities. Teachers will find that it is wise to devote time investigating creativity models which play a vital role in helping students acquire reflective skills. Van Tassel-Baska (2006) observes that "…a few selected models used over time enhances learning more strongly than eclecticism" (p.299). The author recommends viewing creativity models by using a framework involving four categories (Mosley et al, 2005, p. 298):

Domain

- area of expertise
- subject area

Content

- types of objective
- types of product (including knowledge products)

Process

- steps/phases in a sequence or cycle
- complexity
- level in a hierarchy
- type of thinking or learning
- quality of thought/action

Psychological aspects

- stage of development
- structural features of cognition
- nature and strength of dispositions
- internalization of learning
- orchestration and control of thinking
- degree of learner autonomy
- level of consciousness

Teachers should note in their lectures and class discussions that creativity can arise from people with a diversity of backgrounds and personality characteristics. Researchers have used correlational studies involving both well known people and everyday individuals and they identified seven traits of creative people:

- independence of judgment
- self-confidence
- attraction to complexity
- aesthetic orientation
- openness to experience
- risk taking
- self-actualization (Sternberg et al, 2005. p. 358).

Motivation can play a major role in people being creative. Extrinsic motivational techniques can be financial incentives in the business world and grades for students. Yet, these have a limited influence on individual performance because people could continue engaging in activities that are not interesting to them. In contrast, intrinsic motivation to do various tasks can reflect a passion or strong interest and often it is something an individual enjoys doing. A major criticism of contemporary education is the emphasis on curriculum conformity which begins in child's early schooling experiences and continues throughout their higher education course work. Gatto (1992, p. 75) advocates meaningful educational experiences and is deeply concerned about efforts to standardize American instruction. "Whatever an education is, it should make you a unique individual, not a conformist; it should furnish you with an original spirit with which to tackle the big challenges; it should allow you to find values which will be your road map through life; it should make you spiritually rich, a person who loves whatever you are doing, wherever you are, whomever you are with; it should teach you what is important, how to live and how to die."

Amabile (1999) stresses six strategies that can have a positive impact on intrinsic motivation:

- **challenge-** creating learning activities that stretch the student but do not overwhelm them. The individual should be effectively tested beyond their current knowledge and skills.
- **freedom-** instructor can enhance reflective skills by having clearly defined goals that give students the opportunity to complete an assignment in a variety of ways (e.g. Power Point slides or a detailed outline) foster self-directed learning. Changing goals during a project will undermine creativity (Amabile, 1999). Researchers have noticed that great scientists are able fuel their imagination by breaking out of logical human narratives and established ways of thinking about solving problems. Hudson (2006, p. 226) states "we must be willing to subvert the conventional wisdom on which our everyday competence depends."
- **resources-** this can involve the quality of interpersonal relationships between students and between students and their instructors. Also, online academic resources such as access to universities' digital libraries and computer staff. The University of Phoenix has over 20 million full text articles in their online library (UOP Fact Book, 2005). Teachers can access Internet sites such as Cave's (2005) Creativity Web for an assortment of instructional aids such as advice on recording ideas.
- **work-group features**- learning teams who have a diversity of cognitive skills, professional, cultural and educational experiences can enhance creativity. Teachers who create online learning teams can use information from personal biographies at the start of their classes to integrate a degree of diversity into their learning teams. Additionally, if instructors could have students share their learning style with them, it could be useful data to develop more effective and productive course work. Conceicao's (2005) online research discovered that "…a mix of learning styles in a group can make the learning experience more balanced" (p. 5)
- **supervisory encouragement**- teachers play a vital role in helping students work through anxiety when tackling difficult assignments. Professional judgment is needed to know when to give more detailed instructions to students who are struggling because part of the process is learning to be patient when working through complex problem solving issues. Students who lack confidence in their learning skills or fear failure can be encouraged by allowing them to make mistakes and experience the joys of being successful in their work.
- **organizational support**- teacher and students need to feel that their work is important. Teachers can become discouraged about integrating innovative instructional methods into their online classes if the work is rarely affirmed by their organizational leaders. Distance educators can feel isolated at times and it is wise for them to develop professional relationships with other educators to cultivate best teaching practices.

The author utilizes a variety of instructional methods to enhance creativity in online classes. Students enjoy studying ethical case studies such as Hinman's (2002) scenario on a university teacher who lied on their resume about their academic degree. The author has created a series of Jeopardy games on a variety of academic subjects (e.g. American history and leadership theories) and online students are challenged with a diversity of questions. Students can save the Jeopardy Games as a Microsoft Power Point presentation and use it as a learning tool on their computers. The difficult people assignment is another example of fostering creativity and problem solving skills by using work based scenarios (Muirhead, 2006b).

Difficult People Assignment

Your task is to create effective strategies to handle difficult people at work. You are to provide two strategies for effectively working with each of the following types of difficult people. Please write approximately 40-50 words for each of your narratives on the six types of difficult individuals (approximate total of 240-300 words).

The Know-It-Alls
They're arrogant and usually have an opinion on any issue. When they're wrong, they get defensive.

The Passives
These people never offer ideas or let you know where they stand.

The Dictators
They bully and intimidate. They're constantly demanding and brutally critical.

The Complainers
Is anything ever right with them? They prefer complaining to finding solutions.

The Yes People
They agree to any commitment, yet rarely deliver. You can't trust them to follow through.

The No People
They are quick to point out why something won't work. Worse, they are inflexible (Dealing with difficult people, 2006, para 2).

Educators who are seeking to develop constructivist instructional plans and increase their emphasis on creativity should consider reading research studies on those who have tried to implement constructivism into their classes. Black and McClintock (1995) have created an educational paradigm based on the principles of constructivism. The model, called the Interpretation Construction (ICON) Design Model, reflects how cognitive psychology, technology and constructivism can be integrated into instructional activities. There are seven steps to the ICON model (Black & McClintock, 1995, para 2):

- **observation:** Students make observations of authentic artifacts anchored in authentic situations.
- **interpretation construction:** Students construct interpretations of observations and construct arguments for the validity of their interpretations.
- **contextualization:** Students access background and contextual materials of various sorts to aid interpretation and argumentation.
- **cognitive apprenticeship:** Students serve as apprentices to teachers to master observation, interpretation and contextualization.
- **multiple interpretations:** Students gain cognitive flexibility by being exposed to multiple interpretations.
- **multiple manifestations:** Students gain transferability by seeing multiple manifestations of the same interpretations.

The ICON model is appropriate for larger instructional projects which contain the level of complexity and the necessary time to adequately engage in each of the steps. Smaller assignments would probably require deleting the cognitive apprenticeship step due to time constraints (Muirhead, 2006a).

Teachers can foster a spirit of exploration by using difficult and complex online questions based on course readings of articles or textbook chapters. Online discussions represent valuable opportunities for students to make new learning connections to their personal and professional lives. Reflective questions create situations for students to critically examine the subject matter through additional research or carefully reading over their course materials. Discussion questions should reflect a logical alignment with the subject matter. Instructors play a key role in maintaining a disciplined, meaningful and dynamic online dialogs. Students can be anxious or fearful about their online postings because they worry about losing participation points. There is debate about assigning grades to weekly discussions due to concerns over subjective teacher grading procedures (Brookfield & Preskill, 2005). The author has found that students appreciate having their discussion work count toward their course grades. Instructors must establish a clear set of criteria in their syllabus such as the basic number of posted online comments and perhaps the approximate word length of their first responses to assigned questions. Teachers can supply additional guidelines and suggestions to help students better understand the academic expectations and increase the intellectual depth of their remarks.

“It is important to interact with other classmates online by reflecting on their observations and ideas. Your online comments should make a significant contribution to the discussion and that can be demonstrated in one or more of the following ways:

- suggest alternative solutions,
- identify potential or real problems,
- explore new theories,
- offer sound rationale from textbooks or articles when disagreeing when someone's comments, and
- share relevant work and research experiences/knowledge during the weekly discussions” (Muirhead, 2006c, Weekly Participation, para 1).

Educators can affirm the importance of the student’s ideas by their online remarks and sharing specific comments in their weekly grade reports. Establishing creative discussions will not occur if instructors demonstrate either an excessive desire to control student interaction or failure to adequately participate. There are distance education models where teachers are not expected to participate in the weekly discussions (e.g. Columbia University) and this greatly reduces the sharing of expertise between teachers and their students. Brookfield and Preskill (2005) encourage instructors who are from traditional educational settings to take an online course to help them have a better understanding of student needs.

Distance educators can assess and affirm student creativity by utilizing weekly grade reports. The University of Phoenix has an electronic grading system that offers an excellent tool to share detailed feedback on written assignments, Power Point presentations, quizzes, tests and online discussion work. It should be recognized that the instructor will need to devote more time to creating a grading rubric for creativity assignments. Assessment can be more difficult due to the qualitative nature of the creative activities which could increase the level of subjectivity during evaluation and grading of student work. The teacher’s educational philosophy and assessment practices must affirm that adult learners do vary in their needs due to such factors as having different cognitive experiences and educational backgrounds. Therefore, it is important that learning should be more individualized and offer significant connections to their personal and professional lives. Assessment procedures must offer a meaningful bridge between academic knowledge, skills and experiences in online course work to the student’s daily life. Rubrics should be designed to reflect respect for student’s experiences and knowledge while promoting growth (Collison et al, 2000).

The literature stresses the importance of individuals devoting significant amounts of time to a specific knowledge domain to cultivate creativity and expertise. Psychological studies involving grand chess masters reveals that motivation and practice are vital factors which transcend innate ability (Ross, 2006). This has major implications for creativity training and educators who want to encourage creativity opportunities in their classes. Students must have faith in pursuing long term learning goals and projects which might not be rewarded or acknowledged within their academic community. Online universities are not known for placing a high priority on faculty research which can create barriers for starting major projects which require financial assistance (Csikszentmihalyi, 2006).

Perhaps, people are too quick to use the term "expert" which has diminished the original intent of the word. Cognitive psychologists stress that it often takes ten years for a person to become an expert (Anderson, 2005; Schacter, 1996). Schacter (1996) relates that individuals who have “ …a highly refined and powerful form of elaborate encoding that enables experts to pick out key information efficiently and to imbue it with meaning by integrating it with preexisting knowledge” (p. 49). Anderson (2005) notes that experts are skilled at accessing information from their long term memories. The template theory stresses the storage of relevant knowledge that chess experts can access to recall more and larger chess patterns than that of novices. It should be noted that chess experts possess two kinds of expertise: routine and adaptive. The routine expertise enables the individual to do problem solving in an effective and timely manner. Adaptive expertise skills are those which help people to develop strategies that fit the particular situation (Eysenck, 2001).

Research studies on experts have found that skill development and developing expertise were tied closely to the timing, quality and quantity of the deliberate practice. The use of mentors played a vital role by providing guidance, monitoring progress and establishing appropriate goals that would promote optimal growth. Bruning, et al (2004) notes that research indicates that deliberate practice can help less talented people surpass the achievements of those who are more talented. Skill acquisition among young athletes, mathematicians and musicians indicates that individuals followed a similar learning process. The key is having the appropriate guidance and intentional practices that cultivate superior performance. "The best practice occurs under the watchful guidance of a skilled mentor who helps the developing expert set goals and monitor improvement" (Bruning et al, 2004, p. 177).

Today's online universities focus their mentoring efforts on doctoral students to assist them in their dissertation work. Individualized instruction and mentoring are reserved for only a small segment of the distance education student population (Blum & Muirhead, 2005). The author recommends that teachers can use blogs to supplement their classes. Blogging communities are diverse and vary in their purposes and reflect a growing intellectual and creative frontier. Farrell (2005) argues that "academic blogs, like their 18th-century equivalent, are rife with feuds, displays of spleen, crotchets, fads, and nonsenses. As in the blogosphere more generally, there is a lot of dross. However, academic blogs also provide a carnival of ideas, a lively and exciting interchange of argument and debate that makes many scholarly conversations seem drab and desiccated in comparison" (B14).

Conclusion

The author has briefly touched upon the subject of integrating creativity instruction into online teaching. Instructors are essential to insuring that students have the opportunities to demonstrate creativity in their online discussions and assignments. Student curiosity should be continually encouraged by developing a learning climate that stimulates risk taking and exploration of ideas. "*…If the next generation is to face the future with zest and self-confidence, we must educate them to be original as well as competent"* (Csikszentmihalyi, 1996, p. 12).

Discussion Questions

1. What are the instructional challenges associated with having online classes of 5-8 weeks in length when striving to promote creativity in student work?

2. What are some of the ways that online education can have a deadening effect on creativity?

3. What types of educational training, experiences and web based authoring tools do online teachers need to better promote creativity in their classes?

4. Why are the basic differences and similarities between critical and creative thinking?

Post-Discussion Summary

What are the instructional challenges associated with having online classes of 5-8 weeks in length when striving to promote creativity in student work?

Distance educators advocate a self-directed learning philosophy because it encourages personal and professional growth. The concept of self-directed learning is vital to creating an educational setting or environment that promotes creativity and higher order thinking skills. This educational objective is challenged by the reality that the level of cognitive maturity will vary among students and teachers will have teachers to make creative adaptations to their teaching plans and activities. Curriculum changes should not reduce the academic quality of the course work. Online degree program administrators must avoid the temptation to dumb down their curriculum standards to increase their student enrollment numbers. The lowering of educational standards appears to help more students experience a measure of academic success. It really represents a patronizing view of people that questions their ability to effectively take on new intellectual challenges and it reflects an ambiguous view of equity. Furedi (2004) relates "… by treating people as weak and vulnerable individuals who are likely to stumble when confronted by intellectual challenge, such cultural attitudes serve to create a culture of low expectations" (p. 138). Distance education administrators, admission personnel and teachers need to work together to maintain high intellectual expectations for their students and uphold the academic integrity of their institutions.

Charles Adamson acknowledged that geniuses are known for their work ethic but stated "I do not understand why creativity MUST include hard work." There is a degree of playfulness involved in the creative process where individuals reflect on ideas during their leisure moments. For instance, individuals who struggle with writer's block will switch their focus from writing to recreational activities (e.g. take a walk) as a practical way to resolve their writing problems. Therefore, there is a legitimate place for people taking breaks and enjoying relaxing times but creativity is built upon a good work ethic. Sarfo Kwaku Frederick affirmed the value of hard work in fostering creativity but believes educators need to be clearly define the term. Cognitive psychologists reveal that research studies affirm that "creativity does not occur in magical moment of insight; rather, creative products result from long periods of hard work that involve many small mini-insights, and these mini-insights are organized and combined by the conscious mind of the creator" (Sawyer, 2006, p. 74).

Christopher Eliot argued for placing creativity within the context of larger educational goals such as preparation for future work. Eliot believes that online instructors should help students understand the kinds of creative ideas and products that are worthy of respect. A major challenge is guiding student creativity without crushing the spirit of adventure in the learning process. Additionally, he provides instructional advice "I think that one way to liberate creativity is to provide some structure so that students know where to focus their creative energy, which is not infinite. Spelling and times tables should be just memorized, so they are effortless and people can focus on composition of ideas and creative proof of theorems."

What are some of the ways that online education can have a deadening effect on creativity?

Online education holds the potential for vibrant interaction and rich dialog. Unfortunately, online instructional experiences can become quite wooden and lifeless at times. Distance educators and their students can become disillusioned with the teaching and learning process when it lacks a dynamic interactive character. Degree programs can reflect a tightly controlled system that affirms a uniform curriculum and required teacher facilitation techniques but it can drain the life from the learning process. During Muhammad Betz's online teaching experiences, he has found that "the monotony for students towards the end of a 30-hour program is obvious. One group of students recently voiced their frustration with the stifling format of their course assignments in a graduate course on e-learning."

Garrison & Anderson (2003) relates, "a problem with many forms of student to student interaction theory is that they nearly always assume that individuals share a content interest within a shared time space" (p. 44). Students will select certain distance education programs and institutions because they enjoy the freedom to pursue independent studies. Group discussions can be counter productive at times due to misinformation, group think mentality, dominating learners who undermine dialog and conflicts with individual learning styles. Hopper (2003) raises concerns about an excessive emphasis on consensus within learning teams that can foster mediocrity and fail to affirm the creative contributions of independent thinkers. Hopper's graduate online group experiences were very frustrating. "I expected graduate work to put me in close contact with more learned minds, accomplished and respected in the discipline, who would challenge and guide me. I felt disappointed and frustrated to feel so often awash in the bland discourse of novices like myself" (p. 27).

The author believes that part of the problem involves having a rigid learning environment that fails to acknowledge the need for individualized and context sensitive learning. Scott Gray (1999, paragraph 7) offers insights into the nature of online interactions:

> "Good – even great – online teaching will not be –will never be built- because you can not build interaction. You enter into it, like a warm bath (shades of McLuhan) like a familiar suit, like a comfortable home. The online materials are only the tools and components of online instruction hammers and screwdrivers and saws and doorframes and kitchen cupboards and furnaces and wall-to-wall carpeting. They do not – cannot- constitute a home. The pausing, the pacing, the pushing, the pulling, the selection, maybe of this movie, that online resource project, such-and –such project – all of these occur in a dynamic fashion in the classroom, and indeed even to a large degree in online learning. Great teaching adapts and flows. The more personalized, the more context-sensitive such adaptations become, the more full the educational experience becomes, the more like a home, the less like a pile of tools."

Gray's (1999) comments reflect a keen awareness of the importance of having an educational model that provides adequate flexibility for instructors and students to freely interact. Several discussion participants (Williams, Betz and Bolman) advocated online instructional strategies that enabled students to have the freedom to pursue a diversity of learning opportunities.

What types of educational training, experiences and web based authoring tools do online teachers need to better promote creativity in their classes?

Students want intellectually and emotionally engaging dialogs which have connections to their current and future jobs. Integrating creative activities into the online setting remains a challenge for today's instructors who must deal with issues of student readiness and institutional barriers (e.g. course structure). Peters (1998) believes distance education is often delivered within the context of an industrial organizational paradigm. He views distance education institutions as having tightly structured courses with lectures and instructional activities that foster passive students learning patterns. Muhammad Betz and Mark Karstad expressed similar concerns about the business focus of contemporary e-learning organizations can create boring courses that stifle student creativity. Kastad observes that universities are embracing financially cost saving approaches to quickly develop online courses that reflect more of a "cookie cutter" approach. He has worked on computer simulation projects that were based on constructivism principles and students were encouraged to explore their ethical decisions through dialogs on their individual choices while cultivating opportunities for group consensus.

Muhammad Betz has noticed how a growing number of online students are motivated to obtain a degree but demonstrate less interest in genuine learning. Garrison & Anderson (2003) relates, "a problem with many forms of student to student interaction theory is that they nearly always assume that individuals share a content interest within a shared time space" (p. 44). Students will select certain distance education programs and institutions because they enjoy the freedom to pursue independent studies. Group discussions can be counter productive at times due to misinformation, group think mentality, dominating learners who undermine dialog and conflicts with individual learning styles.

There was lively dialog among the IFETS participants about the role of lectures and reading assignments in the online environment. Alfred Bork argued that lectures, long videos and reading passages should be avoided because they create a more sterile learning climate. Sabine Payr rejected the idea of abandoning long texts because reading should be considered a creative form of knowledge construction; "drowning reflection in interactivism can be fatal to creativity: it hinders students in interacting with their own minds-where creativity is to be found, after all." Ros Brennan Kemmis stressed the importance of course content should be viewed as an integral part of the entire teaching and learning process. "Delivering content alone will sustain only the most persistent learners whose tolerance for boredom is reinforced by high levels of motivation to complete."

Muhammad Betz and Katherine Bolman shared how they strived to make online assignments relevant and interesting. Betz related a major problem is the absence of creative expectations and a good student is described as one who has good writing skills, completes written assignments and shares in the asynchronous dialogs. "…I am finding that students are not taking classes online to express their creativity; they are taking online courses for convenience (saving travel, for example) and to get a degree to earn more money." Betz and Bolman acknowledged that online discussions encouraged the production of novel ideas because students can share life experiences and insights from the weekly required readings. Creativity arises from the combination of reading, writing papers and interacting with other students.

Sawyer (2006) stresses meaningful group interaction as a foundation for creativity in education and business organizations. In the educational realm, instructors can foster creativity through building vibrant online learning teams, asking thought provoking questions and encouraging students to take risks in their work. It is important that instructional designers and curriculum staff avoid creating courses that fail to affirm best practices in the teaching and learning process.

Distance education literature advocates teacher training to facilitate best practices and encourage the use of diverse instructional methods and approaches. Janet Salmons suggests instructors should consider being an online student to increase their understanding of online education. Frances Bell commented on the need to view the online setting from the student's perspective. The author has completed various online classes and degree programs from different institutions and has found it to be a valuable resource for communicating with students. Salmon's shares the following practical advice for fostering creativity:

- "Organize learning activities for "structured controversy." Involve learners in discussions and debates, which tackle more than one side of an issue and require them to support arguments with evidence."
- "Organize learning activities for problem solving. Ask learners questions with multiple answers or several equally correct answers. As learners to solve real life problems where there is the possibility of more than one acceptable solution and where several different types of information are required."
- "Organize learning activities that ask learners to present answers using diagrams, concept maps or other visual representations."

Why are the basic differences and similarities between critical and creative thinking?

Terri McNichol works as an artist and historian and expressed frustration with the academic "emphasis on 'rationality' at the expense of creativity." The strong emphasis on student testing is an example of how rationality has been integrated into the curriculum. He mentioned Damasio (1995) who has written *Descartes Error: Emotion, Reason, and the Human Brain* and several books on neurobiology research and the interaction of feelings with human rationality. Cognitive psychologists are recognizing that critical thinking and creativity are connected to an individual's passion for a subject. There are emotional elements in the creative process such as the decision to take risks. Why are students not taking more intellectual risks? Sternberg (2003) argues that students have not been given adequate instruction about how to assess risks and they fear the possibility of failing grades which causes them to "play it safe" (p.115). Sternberg recommends helping students to take sensible risks and teachers should reward their risk taking.

Critical thinking and creativity should be viewed as being part of higher order thinking skills and not mutually exclusive. Walters (1990, pp. 456-457) notes the dynamic relationship between critical and creative thinking

> "Logical inference, critical analysis, and problem solving are fundamental qualities of good thinking, but only if they are complemented by the cognitive functions of imagination, insight and intuition-essential components of the pattern of discovery. The latter serve as necessary conditions for innovative speculations, intellectual and artistic creativity, and the discovery of alternative conceptual paradigms and problems. They facilitate flexibility and adaptability of new ideas as well as novel situations and are thereby essential to the nurturing of responsible, free, and reflective adults and citizens."

Implications for Educators

Today's students want online classes that are enjoyable places where learning expectations are built upon meaningful activities and discussions. Online education is not immune from negative social or business trends which can undermine the teaching and learning process. Christopher Eliot warns "there is a danger in my view; which derives from political and economic reality. It is very easy for funding sources to decide that the easy (and cheap) parts of education are the only things that will be supported, leaving students very poorly served."

Contemporary instructors play a vital role in shaping the intellectual depth of their online communities by helping their students become reflective and self-directed learners. There are definite gaps in the theory and practice of distance education. Alfred Bork accurately highlighted a vital issue, "learning should continuously adapt to the individual learner. This has been possible for over 30 years with technology, but is still rare." Bork recommends more research on the effective use of computer technology to tutor students. He has developed workshops on adaptive tutorial curriculum and is currently working on new book that addresses this important topic.

Bill Williams observed how innovations are known after they are produced but it is much more difficult to understand the processes underlying the creative products. "As educators, I believe we have to more flexible in our thinking and language when trying to encourage these kinds of processes (Williams)." The phrase "fostering creativity" does reflect a greater emphasis on establishing a learning climate that offers students opportunities for cultivating their creative skills (e.g. problem solving). The facilitating element would involve introducing a variety of activities that represent a holistic perspective on the teaching and learning process (e.g. both individual and team work). Williams mentioned the possibility that innovators might have a different set of competencies in qualitative ways. Weisburg (2006) relates that Edison's light bulb and the Wright brothers' airplane had "...components of innovation were based on general rather than domain-specific expertise" (p. 34). Therefore, the qualitative differences between some creative individuals could be certain general skills and knowledge.

The discussion highlighted the need for cognitive research that offers more specific information on how teachers can foster and nurture creativity in their online courses. Future IFETS discussions could devote more attention to critical thinking and addressing qualitative differences between innovation and creativity.

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Price, S., & Oliver, M. (2007). Technology and Change in Educational Practice (Guest Editorial). *Educational Technology & Society*, 10 (1), 14-15.

Technology and Change in Educational Practice (Guest Editorial)

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The collection of papers in this Special Issue of Educational Technology and Society features a selection of the best papers from the Conference *Technology and Change in Educational Practice* held at the London Knowledge Lab, Institute of Education, London in October 2005. The conference was held as part of the Kaleidoscope Network of Excellence, Jointly Executed Integrating Research Project investigating the *Impact of technology-enhanced learning on roles and practices in Higher Education*. The focus of the conference, and indeed this special issue, was on work that explores current trends in technology implementation in Higher Education and research that increases our understanding of subsequent changes in roles and practices of those involved in Higher Education provision. Rather than simply seeking more of the same, however – another case study, one more experiment – we took an active stance on encouraging contributions that offered new perspectives, looking for papers that might change the way that we understood this topic rather than just add to it. This conference provided a forum in which research into these developments could be shared and debated – a necessity, given the way in which contributions sought to re-position the field – and the contributions, together with the discussions that followed, have provided the basis for this collection of papers.

Recent technology innovations have led to a number of claims about their potential for learning. The rapid growth of computing, networks and infrastructure offers not only an increase in available technologies for learning, but also a change in its potential use in education. The subsequent impact of such rapid and diverse technology development on various staff roles and practices is extensive. Much research focuses on the impact of technology on learners, but surprisingly little specifically addresses the impact on the *providers* of technology-enhanced learning. But it is these providers that will ultimately be the key to successful use of technology in education, both in terms of effectively embedding it into educational practice and in terms of its educational value. As such, understanding the effect of technology on roles and practices is critical for the process of adopting technology appropriately within the education system.

Even if research shows that a particular technology supports a certain kind of learning, this research may not reveal the implications of implementing it. Without appropriate infrastructure or adequate provisions of services (policy); without the facility or ability of teachers to integrate it into their teaching practice (academics); without sufficient support from technologists and/or educational technologists (support staff), the likelihood of the particular technology or software being educationally effective is questionable.

One particular set of questions about this process concerns the degree to which technology concurs or conflicts with existing practice or policies, and any subsequent implications necessitating change. How well is it embraced and taken up? How well is it welcomed by those whom it most affects? Sometimes change is not always overt when technology is implemented, and may take place over time as the technology use is gradually embedded in practice. Understanding the underlying mechanisms that hinder or support the processes of change can inform ways of supporting the implementation of other new technologies and engineering the associated changes in practice necessary for their effective educational use.

A further, more comprehensive concern is that this field of research is complex. It currently offers a diverse collection of studies, and lacks a coherent framework for integrating them. This raises important issues for conceptualising impact and change relating to technology enhanced learning, as well as choices of methodology, the execution of empirical studies, and the relevance of this work to the wider research field.

This field of research is of central importance to a number of different disciplines (education, computer science, design), practitioners (tutors, support staff, education developers) and providers of technology-enhanced learning (policy makers). In particular it serves to inform educational policy; staff training, academic and support, and continuing professional development; pedagogy, including effective ways to integrate technology into teaching; design of technologies, including infrastructure, software, and devices; and ultimately contributes to the potential to offer effective technology-enhanced educational practice. Presently, its message is confused; there seems to be little in the way of clear advice that we can offer to any of these groups. This journal special issue seeks to address this problem: by positioning work in the area more clearly, and considering the relationship between technology and its users, we hope to make research more relevant by making it more coherent.

The papers in this issue are clustered into three areas of concern: methodological frameworks, proposing new ways of structuring effective research; empirical studies, illustrating the ways in which technology impacts the working roles and practices in Higher Education; and new ways of conceptualising technologies for education. Given the current stage in development, deployment and integration of technology into education, the papers in this collection provide an illustration of the broad nature of research perspectives essential for developing our understanding of the relationship between technology and educational practice and a focus on change in educational practice and perspectives, actual or potential, arising from the existence of technology. There may be contrasts and contradictions between the papers – but this was our intention from the outset: not to close down the discussion about technology enhanced learning, but to open it up, to look at it in new ways. The research here offers the chance to stand back from the detail of particular studies and consider broader, more fundamental questions. What does this mean? How should we understand it? The variation across the papers included here shows that these debates are still live; they also show that researchers are, increasingly, able to identify distinctive answers to these questions.

Price, S., & Oliver, M. (2007). A Framework for Conceptualising the Impact of Technology on Teaching and Learning. *Educational Technology & Society*, 10 (1), 16-27.

A Framework for Conceptualising the Impact of Technology on Teaching and Learning

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ABSTRACT

Although there is great interest, and considerable investment, in adopting technology within Higher Education, it is less clear what this change means to the people who implement or experience it. Presently, there is no consistent framework used to study and explain this phenomenon. In this paper, we propose a framework that can structure and guide work in the area. Work carried out as part of a Kaleidoscope-funded project (see Price *et al*, 2005) to explore the impact of technology, providing an overview of current research in this area is described, outlining a framework of approaches to researching this topic, and providing an example of empirical work that fits within this methodological framework. Findings from the case study reported here focus on the role that models of teaching and learning play in the process of technology adoption and will be used to elaborate on the themes emerging from the review of existing research. The paper will conclude by considering the framework's role as a foundation for further work in this area.

Keywords

Impact of technology, Teaching roles, Teaching practice, Conceptual framework, Higher education

Introduction

In the current educational climate new promises of technology for education or teaching and learning are widespread. Such prospects can lead to policy decisions about technology adoption being based on rhetoric or assumptions about the effectiveness of technology. In addition the rapid advancement and changing potential of technology further complicates the value of such assumptions. Such policy decisions have far reaching implications but we know little about the actual impact of this on teaching and learning in higher education (Conole, 2002).

Understanding the impact of technology-enhanced learning for staff in higher education is important if better-informed decisions are to be taken about how and why certain technologies can or should be adopted for teaching and learning. By understanding these aspects the process of technology implementation and adoption can take on a form that is more likely to be successful for those that it is aiming to support (namely the teachers and learners). Furthermore, understanding impact informs us about the value of technology for teachers (and learners), informs the design of technology, and suggests ways in which technology implementation can be supported, both from a technical point of view and for personal support.

Since the adoption of any given technology will be influenced by how it disrupts existing practices, it is important to understand how technology changes teaching roles and practices in order to ensure that we make *wise* use of technology (Lea, 2001) by: *(i)* informing educational policy, *(ii)* informing staff development, *(iii)* understanding the best to way to integrate technology into teaching, and *(iv)* informing technology design.

To pursue this agenda, a Jointly Executed Integrative Research Project (JEIRP) was funded under the Kaleidoscope Network of Excellence (http://www.noe-kaleidoscope.org/). The project sought to explore the notion of 'impact' in relation to the adoption of technology, and specifically, to relate this to roles and practices in higher education. The principle outcomes of this project included (i) a review of the literature, (ii) the development of a conceptual framework consisting of a model of 'impact', linked to methodologies suitable for studying this topic, and (iii) examples of empirical work. Each of these will be considered in relation to the wider research field in the sections that follow.

Background

Many commentators argue that technology can transform educational practice, typically as an element of wider organisational transformation such as the development of mega-universities (Daniel, 1998) or as a consequence of competition in international educational markets (Hannah, 1998). Others have taken a less deterministic position, but see a link between technology and changing educational practices such as the creation of more flexible opportunities for learning (e.g. de Boer & Collis, 2005). Clearly, technology is associated with changes in practice but the nature of this association is complex and contested, not least because it forms just one influence amongst many upon academic identities (see, e.g., Henkel, 2000 or Taylor, 1999). Where the influence of technology is studied, it is primarily in terms of novel or innovative initiatives – saying little or nothing about the impact of established technologies, or what happens when use of a technology becomes 'mainstream'.

As part of the Impact JEIRP, a literature review was undertaken that sought to explore these issues (Price *et al*, 2005). In spite of the complexity described above, it was possible to conclude that the introduction of technology is associated with a number of changes:

- Increasingly flexible opportunities for study, in terms of time and location (Bates, 2000);
- The formalisation and industrialisation of curriculum work (Cornford & Pollock, 2002);
- A sense of insecurity amongst educators about their lack of understanding and/or skills in relation to these new forms of teaching (e.g. Mishra & Koehler, 2006);
- A consequent growth in academic development initiatives, generating interest in new approaches to working with academics (e.g. Sharpe, 2004);
- The emergence of new roles, such as learning technologists, raising political concerns about responsibility for areas such as curriculum development (e.g. Torrisi-Steele & Davis, 2000); and
- A changing conception of what it means to be a 'teacher' (Lairson, 1999), which may now be envisaged as a facilitator, organiser of knowledge, producer of educational content, *etc*.

These complexities have not stopped policymakers mandating new kinds of practice, or new areas for development. In the UK, the Dearing Report and the recent government e-Strategy have promoted industrialised models of curriculum development and attempted to introduce standards for the development of electronic materials; in Bulgaria, university-level distance education has been regularised by law, and a loan agreement with the International Bank for Reconstruction and Development has led to the "Modernisation of education" project; and while there is no national policy for teacher development in Norway, this area of work has been promoted by the Department for Church, Research and Educational affairs and is the subject of most universities' strategic plans. However, there is a widespread belief that there is a gulf between hype around e-learning and peoples' experiences (e.g. Conole, 2004; Robertson, 2003), signalling the importance of reconciling these through research.

What was apparent from this review was the paucity of convincing research that was able to reconcile these agendas. This was due, primarily, to the lack of any integrative framework for the area. In the next section, the methodological problems that have led to this situation will be outlined.

Methodological considerations

The situation of change outstripping understanding, outlined above, has not previously galvanised research. To date, there is no unifying methodological approach or theoretical position structuring work in this area. Developing appropriate and effective methodologies for investigating the impact of technology on teaching practice is crucial. Much research so far has been centred around funded implementations, testing preconceived ideas rather than exploring need or even current practice. Other research shows little evaluation beyond the informal 'the students liked it'. The majority of research involves case studies; evidence is rarely amalgamated and there is no clear agenda of research needs. This is understandable, since the complex, shifting context makes it difficult to define terms such as 'impact' and 'effectiveness' (Oliver & Conole, 2003). Without fixed points for comparison, and with multiple influences affecting practice, attributing causality to a particular intervention (such as a new technology) becomes extremely difficult to do in any credible way (Oliver & Harvey, 2002). More specific evaluation looking at the difficulties as well as what went well would inform us better on the overall impact of the technological implementation.

One thing is evident - that there is no obvious research method to adopt in relation to this problem (Price et al., 2005). Instead, different approaches seem well suited to particular aspects of this field. In response to this, it is proposed that these issues can be clustered according to the kinds of research approaches that are suitable to use when studying them. Reviewing work in the field to date, it was possible to distinguish between studies that used different kinds of data as evidence of impact. These differences are significant, in that they reflect fundamental differences in how 'impact' was conceived within the research. Classifying research papers according to their epistemological commitments, we could distinguish between work that sought to *describe* impact, work that sought to *explain* how impact took place and work that, in effect, *conceptualised or promoted* particular kinds of outcomes.

Consequently, we suggest that one way to group these research issues is as being:

- Anticipatory (such as the discourses and rhetoric of policy, design and intentions, opinion and attitudes);
- Ongoing (processes of integration, including practices of staff development); or
- Achieved (summative studies, particularly of technology that is no longer considered 'novel').

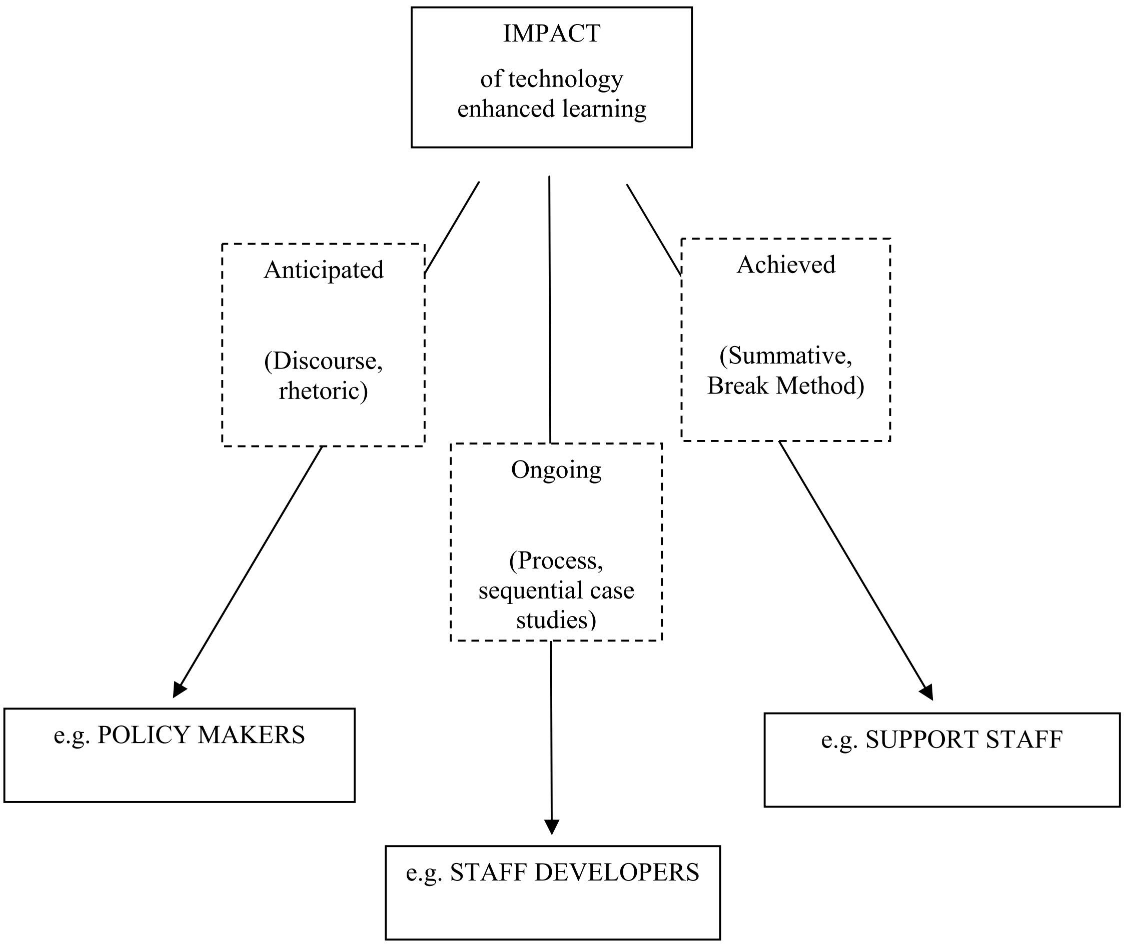

Figure 1: An overview of approaches to the topic, indicating example audiences

The underlying nature of each of these 'positions of technology' differs and suggests the employment of different methodologies. For example, *anticipated* impact might be studied using discourse analytic approaches; to understand the impact of *processes* of integrating technology a longitudinal method may be appropriate, perhaps involving sequential case studies; to understand *achieved* impact might require retrospective evaluation or the identification of the practices that rely upon a particular technology. Figure 1 shows the structure that framed the empirical work undertaken in the project.

This framework was designed to highlight the link between varied conceptions of impact and the research methods deemed appropriate for investigating the topic. The purpose of this is twofold: firstly, to explain why the research in this area to date has been so fragmented; and secondly, to help guide future work in this area. If impact is conceived of as an ongoing social construct, negotiated through discussion (e.g. Shaw, 2002) then a summative review is inappropriate; what is required is a study of the way in which people use talk (and text) to achieve particular changes. If impact is understood as a change in the structure organisation, as defined by its policies and procedures, then such ephemeral talk is incidental; it becomes more important to focus on the policies and strategies that define institutional working (de Freitas & Oliver, 2005). However, if what is sought are assurances of the value of some approach, or promises of this success being replicable elsewhere, then comparative studies and experimental designs might be appropriate.

In effect, this framework has enabled us to identify three traditions of work that, whilst they may complement each other, cannot easily be conflated; each proceeds according to its own tradition of knowledge production and legitimation. Rather than attempt to address all of these, then, it becomes important to locate work within this area in relation to one of these strands of work in order to position it (and the researchers' assumptions) more clearly.

In addition to helping us identify appropriate methodologies, this framework suggests communities that would best be informed from outcomes of each of the strands of empirical work. The groups indicated in Figure 1, for example, are not the only people who might be interested in work of this kind. However, they are useful examples of distinct groups who might have an interest in particular questions that would form part of each tradition of work. It is relatively unusual for research work to be explicit about its intended audience; this is something far more common in evaluation work (Patton, 1997). Following the spirit of Patton's utilization-focused evaluation work, whilst we recognise that various groups (academics, for example) might have a general interest in work in any of these traditions, certain groups are more likely than others to actually act upon research outcomes of particular kinds.

So, for example, studying the *process* through which technology has been adopted might inform staff development strategies, whereas studying the *achieved* impact of some initiative would inform us about successes and difficulties in practice, which may be of direct relevance to the work of support staff. Academic staff themselves, of course, might be interested in any or all of these areas.

This framework was used to guide the empirical work undertaken during the project (fully described in Oliver *et al*, 2005). A series of case studies to explore the impact of the implementation of a 'new' technology on the roles and practices of academic staff in higher education were carried out as part of the 'ongoing' strand of research. To illustrate this, a selected study from the empirical work is presented below, focusing on the impact of technology on the role that models of teaching and learning play in the process of technology adoption. It would be impractical, within the scope of this paper, to attempt to illustrate all three traditions, described above. Consequently, the study reported here focuses on the process of technology adoption, and its relevance to a particular audience (staff developers) will be considered at the end of the analysis.

Methodology

Teachers develop particular models of teaching and learning, which are used to inform their teaching practice. From the initial literature review (Price *et al*, 2005) a series of questions were identified that were pursued in subsequent empirical work. Do these models influence the way technology is used or does technology enable new models of teaching and learning to develop? What role do teachers' models of teaching and learning play in the implementation and use of technology? One question is whether integrating technology into teaching results in a change in teaching practice or just a transfer of a particular practice from one situation to another, e.g., communication from face-to-face to on-line.

This case study explores the impact of technology implementation in the initial stages of adoption of Blackboard (a virtual learning environment) into two different courses within a Higher Education University. One course involved a pilot study set up by the university to trial the use of Blackboard in a PGCE course, with a view to more general implementation in the following year. The pilot study involved all administrative and academic staff on the PGCE course. The other was an innovative project to introduce Blackboard as a way of supporting learning through discussion groups for doctoral students. The primary function of the technology here was anticipated to support voluntary discussion groups, both as on-line discussion and to build on face-to-face interaction. The main function of the discussion groups was to provide personal learning support and social interaction for the doctoral students.

As the focus here was on understanding how academics made sense of the changes in their practice, a series of interviews were undertaken to enable us to explore their own explanations and motivations. Interviews included four academic staff, three of which were subsequently interviewed after a period of one month, and with two members of staff with a remit for supporting pedagogic uses of technology.

Initial interviews took place prior to technology implementation to find out the participants attitudes towards institutional policy, the technology and its perceived utility for them and their teaching, and their anticipated understanding of the impact that this technology for them. Subsequent interviews were undertaken to compare these positions with opinions after implementation had begun, to establish whether or not previous expectations were realised. Semi-structured interviews were designed to ensure that appropriate information was elicited, but also to allow for unanticipated responses and facilitate more detailed exploration of views that may contribute significantly to the data.

Each initial interview was structured around the respondent's perceptions of the following: the rationale for using the chosen technology, its features and functionality, the policy decision and manner of implementation; the perceived benefits and/or disadvantages for teaching and learning; the perceived effects on teacher/ learner roles; anticipated difficulties, including individual concerns; expectations regarding training and their familiarity with technology (the proposed or otherwise). Follow-up interviews were structured around the following, with additional questions arising from the first interview particularly relevant to each individual: how the implementation was progressing; how they felt about the technology now; ways in which the technology has been useful or not; ways in which the technology has affected teaching practice and/or role as a teacher; their need for training. All interviews were recorded and then transcribed for analysis.

The first step in the analysis involved identifying specific instances that related to themes from the literature review. Analysis of this complex, emergent relationship between practice and technology can be undertaken using the perspective of Activity Theory (Kuutti, 1996). This involves analysing the way in which people (subjects) use tools (which may be physical, symbolic or conceptual) to achieve objects (intentions), within the context of a community that maintains certain rules (tacit codes of practice) and organises work in particular ways (the division of labour). This form of analysis draws a distinction between different levels of activity: the activity itself (a strategic-level description of intentional tool use in context), the series of actions that constitute it (specific conscious uses of tools, in context, to achieve tactical components of the overall task) and the myriad operations that constitute each action (each of which is so simple and routine that, unless a problem occurs, we remain unaware of undertaking them; they are not consciously perceived). This distinction allows the creation of nested accounts of practice that encompass both strategic and 'automatic' acts.

Finally, the results of this analysis were considered in relation to the audiences identified in figure 1, to draw out implications for action. Outcomes from the interviews presented here focus primarily on findings related to the impact of this technology implementation on models of teaching and learning, and corresponding implications for the process of technology adoption, and staff development, support and training.

Findings

Current models of teaching are frequently used to underpinning predictions of ways in which technology will be used. Respondents in this study often talked about their predicted role or practice in relation to their current teaching roles or practices. For example, one teacher providing a support role on-line equated this with a similar support role in face-to-face situations; the role of teacher as facilitator on-line was equated with that of facilitating any teaching situation; dissemination of information on-line expressed as being similar to using e-mail or paper in face-to-face situations.

This attempt to reuse familiar practice in a new context may be appealing (since it attempts to build on established expertise and an extant professional identity) but it is problematic. The degree to which such practices can be transferred from one situation to another is unclear, raising the question of whether such a change in technology necessitates a change in approach, too. In other words, within these case studies, is it just the tutor's perception that they are merely transferring the same practice from one situation to another, rather than requiring the practice itself to change? Or, because of the new context, environment or technology, is practice necessarily modified, with *emergent* changes in practice arising as a consequence? To explore these issues, several examples can be highlighted from this study:

Models of learning by discussion

Several respondents in this study highlighted the significant role that peer support plays in learning on PGCE and doctoral courses. In traditional teaching settings this support often takes place in familiar ways, such as, face-to-face discussion. Berge (1995) identifies the importance of social interaction on-line as being critical to the success of such group interaction, in developing group cohesiveness, unification and working towards mutual goals. Hand in hand with the desire to facilitate this kind of interaction on-line, is an underlying assumption that technology will provide the medium to do so. However, experience suggests that achieving this is fraught with complexity, due to the permanent and public nature of on-line expression. One respondent observed:

> "As trainee teachers they go through some fairly traumatic self assessments and finding they're not very good at it at first. Whereas in face to face situation you can make it very comfortable for people to talk about problems that they're having – people will say they've had a terrible session, they were terrible etc.. and then we can talk about it. On-line there's a marked difference writing such things in text and to remain for the duration of the year because they were terribly aware that to be candid was very exposing – your tutors on-line, it's in text, it's on the record and the desire to appear confident was extremely important to them when they were on-line."

In contrast, on-line discussion groups were also highlighted as being useful in supporting learning, by enabling students to share different perspectives, especially about their experiences in their teaching practice.

> "They will go into their school for example, talk about lessons and assessments and go on-line and discover that there are various different ways of doing it. And there is some discussion usually about the pros and cons of the different systems…. they find that there isn't one best way… here's a diversity and they understand that there's a diversity of approach."

This was seen as especially important given the range of approaches to teaching and students' physical isolation while on teaching practice, and is seen as critical to enabling them to be more self-reflective. Another respondent also pointed out the huge impact that on-line discussion groups can have on teaching and learning. In this case on-line discussion was task driven and carefully crafted. Students were required, for example, to share what's going on in their experience in schools and learning in other contexts, to comment on each other's experiences, and to critique various bits of input from tutors. The awareness of others on-line, and the asynchrony of interaction were thought to make an impact on the quality of communication. For tutors this means taking on the role of 'moderator', which requires the skill to appropriately craft tasks, to comment at the end of the discussion, but generally not to intervene in between. This kind of practice can support students (here trainee teachers) to "learn in very self sustained ways, collaboratively without the need for constant tutor intervention". In this environment participation was compulsory, but not assessed, similar to the requirement to attend face-to-face seminars but contribution itself is not assessed.

Research also suggests the importance of students feeling *'safe'* in an environment for dialogue and communication to take place (Salmon, 2004). In an on-line environment it is harder to know how people are judging you by what you say and how you express yourself due to the lack of other familiar social interpretive clues that go along with face-to-face interaction or even voice-to-voice interaction e.g., facial expression, tone of voice. One respondent emphasized the importance of creators of discussion groups being aware of such issues:

> "So I think that illustrates the complexity of what is going on here and what people feel when they're typing something in about, well what is this going to say about me, what will other people say, how will they judge me. And there's all this going on that perhaps when people are less experienced in creating a group they wouldn't really think about it."

Such complex interaction between the technology, the situation and students' needs can affect the amount and kind of dialogue that may take place. In addition, the dialogue is 'public', 'permanent' and 'reviewable' in a way that conversation is not, thus potentially changing the nature and content of interaction. This can apply to discussion about learning topics, as well as personal issues. For example, Hammond and Wiriyapinit (2004) found that although on-line groups were active within discussions, they were restrained when there was potential for disagreement, maintaining significant levels of politeness. Such interaction is likely to reduce the degree to which critical reflective learning can take place.

Role of facilitator

Part of a teacher's role in traditional face-to-face teaching is being a facilitator of learning, and this role is seen as being equally important in technology mediated learning situations.

> "I think […] the role of the facilitator is key. And I think the role of the facilitator in any learning event is key, and the stance that they take and the way in which they take up either the new technology, or any change in classroom practice in a face-to-face situation, will determine the response of the participants."

In order for such technology-mediated groups to be successful the role of a facilitator is considered central – as in any teaching situation. But how much does this perception depend on the rhetoric of 'teacher as facilitator' without yet thinking about what the role of facilitator really means?

In this case study the role of facilitator with Blackboard was expected to take on various forms. One included planning discussion sessions as well as aiding the progress of discussion.

> "If I were facilitator, then yes I think it would because I would need to plan, I would need to spend time thinking what I would need to say to the students, how to get the discussion going, how often I need to look to see of there are any messages. …. I think I'd probably need to think about it in some way every day."

A further expected role of facilitators was 'modelling', which was claimed by one respondent to influence the style of interaction. For example, the facilitator could engage by sharing unpolished thoughts and ideas, thus encouraging students to do so. Indeed, as part of the 'necessary conditions for successful online instruction', Berge (1995) proposes that modelling appropriate online behaviours prepares students for engagement in independent online interaction.

Another important facilitator's role was to create a 'safe' environment for the students to interact in, where they would feel comfortable and confident enough to engage in discussion. For example, feeling inferior to other students may affect how much and how often they participate.

> "When I went to the first session [beginning of the course], one of the questions was, 'What do you fear?' And people said 'Well I fear that I'm not up to the level' and that's a really important thing too."

However, as the technology implementation progressed initial expectations of the role of facilitator began to alter, and other ideas for this role emerged, according to whether the facilitator was a tutor, a member of the teaching and learning support staff or a student.

> "Of course there might be a time where I started a group off and its perfectly fine without me, or I could see some person in it that I'd think, ah they'd be good, they'd be better than me, I'll encourage them to facilitate. And then I could just step away and look at it occasionally."

Another respondent described the nature of interaction as different online than in face-to-face situations, influencing the role that the teacher plays as 'facilitator', e.g.,

> "The way we craft the tasks is such that *they* talk on line, we as a moderator only comment at the end of a discussion, unless there's a serious reason for intervening, we let them talk. In a face to face seminar, I can't imagine not talking myself as a tutor, although we carefully monitor ourselves not to dominate, and all the rest of it, and the end of the day in the discussion, you join in don't you."

In summary, this study revealed a number of differences and potential changes to the role of facilitator in on-line discussion groups, for example, the identity and roles of participants may change if students take on the role of facilitator. This may be the same role in name, but when transferring a concept already employed without technology to a technology-mediated situation, the particular role or practice involved may be different.

Role of tutor as support/ monitor

Teachers also see themselves as taking a role in monitoring students, both in terms of supporting their motivation and learning, and in terms of attendance. But does it change with technology, or differ in an on-line environment such as Blackboard? One respondent considered student support to be especially important for maintaining student motivation for continuing the course, and described this support role as being the same within a virtual learning environment (VLE) as within a physical learning environment. A VLE system (not Blackboard in this instance) that was originally being used enabled monitoring of student interaction. This was used to assess levels of motivation, and where concern was raised, allowed appropriate input by the tutor. Such intervention was considered successful on a number of occasions, and was taken as evidence (by the participant) that face-to-face practices had been transferred to on-line teaching. In a face-to-face situation, signs of diminishing motivation were, for example, non-attendance or reduced contribution at meetings. Similarly, in the on-line environment this respondent is looking for signs of disinterest, unhappiness, or loss of motivation in a student early enough to intervene.

> I'm looking for some kind of contribution, any contribution, I look for basically and if I don't get that then I know there's probably something wrong. It's when people are chipping in their bits and then all of a sudden it goes quiet. That's the danger sign. You do pick up on odd stuff like that – its just transferring what you normally do in normal situations to a virtual environment.

Monitoring student attendance at seminars or lectures is another role that tutors see themselves as already undertaking, and is a fairly commonplace and accepted practice. However, monitoring student interaction through use of discussion boards was perceived as a challenging issue by two respondents in this study. Concern was expressed over the potential to become too "Big Brotherish", with the facility to monitor all input, and the potential for value judgements of inputs to be made in ways not possible in transient face-to-face situations (cf. Land & Bayne, 2005). This raises several questions that need to be considered in the process of adopting this technology.

Analysing the findings using Activity Theory

The findings here suggest that preconceived ideas about mappings between technology characteristics and teaching/learning practices may need to change. The degree to which transfer of practice can occur without modification seems to depend on the function of the practice itself, with some practices being more easily transferable than others e.g., monitoring student interest/ input as oppose to discussion, especially of a personal or emotive kind on-line. Reaching a good understanding of the complex relationship between technology, context, interaction, learning outcomes will be an ongoing evolving process, requiring a certain amount of adaptability from both staff and students.

Within an Activity Theory conceptual framework it is possible to revisit the cases outlined above to provide a deeper level of analysis. For example, consider the support provided by the tutor. At the strategic level (the level of Activity), the move online results in no significant change: the overall object is still that the tutor provides support to their student, looking for signs of disinterest or unhappiness. This remains the tutor's responsibility, and the tools used (watching for symbolic events such as non-participation) are the same. This explains the claim that the role of the tutor remains the same within the new environment.

At the level of actions, however, differences start to emerge. The way in which signs of non-participation are noticed changes. Rather than looking for non-attendance by glancing around a room, the same object is achieved using a different tool – such as the student monitoring functions within the virtual environment. Thus, although the object remains the same here, the system as a whole (the inter-relationship of subject, tool and object in their social context) changes, not least because the tools being used are now different.

At the level of operations, the differences are substantial. Rather than operations such as ‘scan the room’, ‘listen for things to go quiet’, there are now operations such as ‘click this link to generate a list of contributors’, ‘click this link to reveal students’ patterns of reading the online materials’, and so on. The entire activity system at this level has changed. At this fine-grained level of analysis, the role of the teacher is almost entirely different online than face-to-face.

What this reveals is how the move to teaching online renders the role of the teacher both the same *and* different *simultaneously*. The purpose and strategic direction may remain unchanged, but the methods of achieving this alter in significant ways. This also explains a number of related phenomena, such as the relatively frequent breakdowns in teaching online (compared to established teaching), until the new operations that are required are mastered. This means that a higher level of effort and commitment is needed *until operations become routine*. It also explains how successful practice becomes invisible – once the breakdowns at the operational level are resolved, this entire layer of teaching is undertaken without conscious intervention. (This makes it even more likely that successful teachers online will see no real difference with their teaching face-to-face, because they will become unaware of the majority of the ways in which their practices are different.)

This echoes Cousin’s analysis (2004) of the metaphors used for VLEs – the way in which they act to preserve a sense of conventional classroom teaching (or at least, those parts most amenable to measurement and automation) in order to provide teachers new to teaching in this way with “a stable transition” (p.121). One potential consequence of this, Cousin notes, is an attendant conservatism in forms of teaching. However, the analysis offers here provides some explanation of why this conservatism might arise – and why teachers might view it as a good thing, because it preserves their sense of what is important about teaching.

However, it does seem likely that components of these systems might be differentially affected. Tools will change more often than objects, for example. In particular, it might prove interesting to study the rules that govern behaviour in different settings, since it is not clear how these differ.

Implications for staff development and training

As outlined in the methodology, the final step in the analysis was to consider how the findings related to specific audiences. In this section, the implications of the above analysis for those who work with academics will be considered.

These interviews brought to light important issues surrounding the use of technology that point to the central role that staff development could play in the design and implementation of technology for teaching. A primary focus for the participants was on how to use the technology, and developing technological expertise. Providing ongoing and flexible training that presents the technology in a straightforward way, promoting a positive and relaxed attitude in staff towards the technology itself, is clearly essential.

However, the rhetoric surrounding technology innovation is well known to raise expectations of what can actually be achieved with technology. Knowing the limitations as well as the potentials of particular technologies in relation to teaching and learning would enable staff to have a more realistic view of what the technology can do, and a clearer understanding of how it might be integrated into their teaching practice. Weller (2002) points out that teachers need to have much more than just technical competence if they are to be successful online: “they need an understanding of the dynamics of online communication and interactions and need to learn effective ways of facilitating and teaching online”.

Another interesting implication is that personal learning (as opposed to formal training) has an important role to play in the process of adoption. One respondent researched other people's experiences using on-line communication technologies that indicated potential pitfalls and failures, and was usefully integrating the findings into the planning of the technology use. For example, Cowan's (2005) research revealed trainee teachers' feelings of vulnerability in discussing their experiences in online groups. This resulted in the respondent thinking in more depth about how to work with the technology to achieve her goals. Understanding more clearly how dialogue works on-line, what kind of dialogue students do and don't engage in, may be an important part of the process of adopting communication technologies.

Furthermore, accounts were given that exposed differences in action and interaction when integrating technology, and the potential implications for models of teaching and learning. Exposure to a range of models of technology use during these early stages of implementation could form a productive part of staff support. Understanding differences in interaction with technology and how this affects learning is crucial to designing effective activities, content and learning goals. "Learning to use technology to effectively mediate the communications process is a critical skill to be acquired early in the teaching process" (Gunawardena 1992, cited Collins & Berge 1996). A superficial reading of this might suggest that this will lead to generational differences within the teaching population; however, there is more likely to be a link with length of service than age *per se*, and the use of the singular – "technology" – hides the ongoing introduction of new tools into teaching, which will result in a fairly complex profile of people conversant with any specific kind of resource, whose skill may or may not remain relevant over time, or who may choose to 'skip' a particular technology but engage with the next.

Conclusion

Although there is great interest in the impact of technology on education, work in this field has been fragmented. In this paper, a framework for studying the impact of technology has been described and applied. The primary outcome of this work has been to demonstrate the usefulness of the three-part model for studying impact. The division into anticipated, ongoing and achieved impact has proved helpful both in organising the work and in terms of the selection of research methods.

The study outlined above can do no more than illustrate one tradition of work. In doing so, it provides a partial instantiation of the research framework outlined earlier. Further studies – such as those outlined in Oliver *et al* (2005) – would be necessary to demonstrate the other traditions of work.

Importantly, however, this case demonstrates a number of principles that arise from using the framework. Firstly, it was unnecessary to consider policy reviews or comparative studies; such research was only of indirect relevance to the particular understanding of 'impact' being explored here. This is useful when synthesising existing research, enabling a more systematic approach to be taken without resorting to a dogmatic position on research 'quality', defined purely on methodological grounds (Oliver & Conole, 2003). Secondly, as a corollary to this, locating work within one tradition simplifies the research design process by suggesting a relatively contained variety of approaches suitable to studying problems of this type. Thirdly, the framework directly addresses the problem of research utilization by drawing on principles developed in the field of evaluation. The explicit emphasis on audience serves to raise awareness of this, although it is only a first step towards improving the processes of producing and using relevant research.

This framework can thus act as a foundation for ongoing work on this topic. The clarification of related but distinct conceptions about what 'impact' might mean has helped to disambiguate existing research claims; in doing so, it has enabled the development of a more principled approach to the design of work in the area. Whilst the framework is not definitive – further work could be undertaken to refine it – it does, nonetheless, represent a step forward in thinking about research in the area.

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From Effect to Effectiveness: the Missing Research Questions

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ABSTRACT

For many researchers and developers in information and communication technology in education (ICTE), the transfer of knowledge from research into educational practice is slow and limited. For most researchers concerned with changing practice, the failure to make a significant impact is attributed to those who practice in education, whilst those in practice see technical research as irrelevant to education. This paper argues that a comparison between research in healthcare and research in education, at one stage disparaged, is informative. Research in healthcare is expected to pass through a number of distinct stages, from small-scale, laboratory-controlled experiments to large-scale trials. Research cannot be integrated within healthcare delivery until these stages are complete. This paper uses this model to argue that intermediate stages between research in ICTE and changes in educational practice are currently omitted or ignored. A 'road-map' is provided to characterize the distinct research questions that should be expected at each stage. Without completion of all of these stages, those in educational practice might argue, justifiably, that there is no warrant to change how education is delivered.

Keywords

Evidence-based practice, Quality of evidence, Effectiveness, Technical innovation, Education-care

Introduction

This paper is concerned with exploring the gap between research in information and communication technology in education (ICTE) and its implementation within educational practice. The paper draws on models and theories of evidence-based practice to suggest that there are a number of distinct phases to be completed before 'research' could be considered sufficiently robust to validate a change in practice. Rather than presuming that practitioners in education are resistant to change, the paper questions whether the evidence that is produced by researchers in ICTE can be seen as sufficient to warrant a change in practice in education.

The paper starts by identifying a set of issues that should underpin the application of evidence-based practice to education. A systems approach is used to draw an analogy between healthcare and (analogously) 'education-care'. There is no presumption that precise standards from healthcare could, or even should, be applied, but key principles are argued to be directly relevant. This approach is then extended to compare the introduction of a new therapy in medicine and the development of a new application of ICT in teaching and learning. This analogy raises questions that are accepted as obvious in healthcare, but which are seldom raised in ICTE, (cf. flip-flop technique in grounded theory, Glaser & Strauss, 1967). Once raised, the validity of these questions does not depend on the analogy itself. If the questions are relevant in the new context (i.e. transfer from research to practice in education), then this is all that is required. From this point the analogy offers a guide to potential answers to these questions, which must be assessed within the new context.

Drawing on central principles from evidence-based policy and practice in healthcare, this paper argues that improving the quality of research itself will remain insufficient to justify the transfer of current research to a change in practice by professionals. Instead each 'new idea' must be taken through additional stages, each of which is characterised by a related, but distinct, research question. Each of these questions must be addressed before researchers have the right to claim that professional practice should change.

From evidence-based policy to evidence-based practice

The first clear exposition of evidence-based policy in healthcare was published by Fletcher and Sackett (1979) as a reassessment of the annual health check in Canada. This study provided the first attempt to collect and assess all the knowledge that could be relevant to designing a programme for wide-scale adoption. The most immediate conclusion of this study was that most of what had previously been treated as 'evidently' true was seldom backed by evidence of sufficient quality to justify the conclusions. Faced with the volume of potential evidence that could be considered, a systematic approach was developed to search for what could be relevant, to assess the relevance of the published research and determine the strength of the recommendations that could be made. In doing this, Fletcher and Sackett identified principles to report the conduct and outcomes of any research on which the decision to license any new treatment is made (Moher *et al.*, 2001; Cochrane Collaboration, 2005).

In education in the UK, as elsewhere, there is a similar view that government policy should be based on evidence (e.g. Blunkett, cited in Taylor, 2004) though there are few who would claim that this is so (e.g. DfES, 2002; OECD CERI, 2002). From this perspective e-learning could not claim to be better. This has revived the debate concerning whether the same standards could ever be applied to education (Hargreaves, 1996; Hammersley, 2002; Simons, 2003) or e-learning (Oliver & Conole, 2003). The debate is not necessarily helpful and can be seen, too easily, as a simple conflict between 'good' and 'relevant' research. For many researchers in education this is treated as sufficient grounds to reject, out of hand, any attempt to compare models of research in education with those in healthcare.

In contrast, a less divisive characterisation of the research in this field has been proposed by Oancea (2005). She separates the educational research community into 'intellectuals' and 'technicians'. Intellectuals are engaged in understanding the complexity of education and in providing tools and results for other researchers in the field to use. The benefits of this research are not intended to be directly applicable to practice and may well seem contradictory, e.g. conflicting definitions of assessment and learning. In contrast, technicians are those who are concerned that the results of their research should be applicable to practice. For technicians it must always be pertinent to ask whether the evidence that they present is sufficient to justify any recommended change in practice. If the research base in a field is insufficient to justify the development of evidence-based policy, then the need for practice to be evidence-based becomes focused on the individual practitioner rather than the institution or government. It is to the technician researcher that this paper is addressed.

The analogy is first drawn at a system level, and is outlined following a soft-systems approach (Checkland, 1999). This allows for the objectives of different stakeholders in the system to be recognised. This analogy is then extended to compare two parallel activities: the replacement of one part of a course with an ICT-based element and the introduction of a new drug. Within this analogy we revisit two key issues raised by Fletcher and Sackett in 1979, and explore two questions that researchers need to address in order to present research that could warrant technical innovation in educational practice. The first is termed the 'quality of evidence'; the second draws critical distinctions between phases of research.

Table 1: Components of CATWOE description.

The customers:	Those who receive the service
The actors:	The people within the organisation that collaborate to deliver the service/achieve the transformation
A transformation:	The change that is created by the system
A Welstanschauung:	The world view that justifies the purpose of the system
The owners:	Those who direct/finance the organisation
The environmental constraints:	The controls that exist outside the system that limit what is possible

The analogy

In this section it is argued that the introduction of any new approach to teaching and learning, on the scale that is expected by researchers in ICTE, is parallel to the introduction of a new therapy within healthcare. Practitioners in healthcare, and their patients, should expect that any new therapy should be demonstrably better than what is currently used, through well-founded research. Practitioners in education, and their students, equivalently, should expect the same standard of research practice before any new approach is adopted for teaching and learning.

The analogy between the two systems is first established using Checkland and Schole's CATWOE analysis (Checkland & Scholes, 1991, p. 37). This identifies six key components within a system (see table 1).

These are outlined in parallel for the healthcare and education-care systems (see table 2, below).

Table 2: Comparison of Healthcare and Education-care systems.

	Healthcare system	**Education-care system**
Customers:	Members of the general population who present themselves with a specific condition.	Members of the general population who present themselves with a specific educational need.
Actors	The doctors, nurses and other healthcare staff - technicians, administrators, etc.	The teachers, lecturers and other support staff - technicians, administrators, etc.
Transformation:	Restoring the customers to the best possible health through the use of the best possible therapy	Providing customers with additional knowledge through the use of the best possible courses
World view	Each individual wishes to be able to participate in society unimpeded through loss of health that could be improved by available therapy	Each individual wishes to participate in activities in society unimpeded through lack of knowledge that could be gained from suitable courses
Owners	The government who control the overall current finance and future investment	The government who control the overall current finance and future investment
Environmental Constraints	The total cost of the system; therapies that are known to work; the differing effect of applying therapies on individuals; the ability of actors to apply therapies.	The total cost of the system; courses that are known to work; the differing effect of individuals studying different courses; the ability of actors to deliver courses.

(Note: The term 'Customer' is used here as the recipient of the service)

The analogy is primarily established as an equivalence of the 'owners' of each system. In each case the government would claim the right to expect that the overall transformation will match expectations.

Table 3: Extended analogy.

	Healthcare System	Education-care System
Expert Actor	Doctors and consultants from relevant healthcare groups	Teachers/lecturers and tutors
Support Actors	Junior nurses and technicians, (radio-technologists, etc.) …	Librarians, technologists, ICT specialists, support teachers
Resources	Drugs, scanners, databases	Course materials, ICT systems, libraries, repositories …
Options for Expert actors	A range of therapies for patients to follow that are appropriate for treating a specific condition.	A range of courses for students to follow that are appropriate for a specific educational need.
Expected Customer Response	The regime that is expected to be followed by an ill person to optimise the effect of the treatment.	Active participation in teaching sessions, completion of teaching materials, assessment etc.
Owner Controls	Government regulations that control the range of therapeutic treatments that can be used (e.g. NICE guidelines), government targets	Inspection to ensure that the standards achieved meet Government expectations on behaviour and exam performance including, in some cases, conformance to a limited number of 'correct' ways to teach, the national curriculum

Three issues could be viewed as potential differences between these systems. Firstly, customers in healthcare typically elect to be treated, whereas much of early education is compulsory – although attendance does not, of course, imply participation. Secondly, healthcare is typically focused on an individual, whereas delivery is more often group-based in education. Thirdly, healthcare can be seen as a service that restores individuals to, or as close to as possible to, 'normal' health. Education is more typically viewed as supplementing the ability of individuals. None of these differences is as clear-cut as stated and each begs further questions in themselves. Although these differences are noted at this stage, they will remain pertinent only if they invalidate the questions that are raised by the analogy. For now, some patience is requested of the reader to follow the main argument through. Issues that relate to a transfer from medicine to education are considered next in defining the analogy at a more detailed level.

This general context needs to be extended to cover distinctions between the actors and the decisions for which they are responsible (see table 3). This table allows for a more detailed discussion of the resources that are available, the range of choices that are allowed to actors and the control mechanisms that are used by the owners to constrain the behaviour of the actors.

At this level the role of the expert actor matches Eraut's generic model of decision making in professional practice (Eraut, 2003). Eraut identifies three sources of knowledge that a professional will integrate to determine the appropriate choice in any sequence of decisions. These include: relevant knowledge from research; specific, case-related information; and professional expertise gained through experience and previous practice. When evidence-based policy is available, it could be argued that this mediates between the volume of knowledge from research and the practitioner. However, this does not reduce the relevance of the other components. Neither does it remove the need to reassess any evidence within the specific context of each decision - as Jadad notes with specific reference to evidence-based practice in medicine (Jadad, 1996).

Table 3 makes no assumptions regarding the extent of ICT integration within any course. It can cover the range of technology-free systems, blended learning, open learning and, potentially, systems that are devoid of human intervention in their delivery (cf. Atkinson's argument, 1993 on the nature and location of a library resource). The replacement of one part of a course with an ICT-based element is parallel to the introduction of a new drug. Just as there can be no presumption that a drug is 'better' because it is new, there can be no presumption that any specific level of, or novelty in, ICT must be better. The next stage in the analogy extends the context to a framework in which a practitioner is expected (by the researchers) to change practice.

Interpreting the evidence-base

In order to provide the necessary link between research in ICTE and change in educational practice, we revisit two specific issues that are taken from the Canadian study. We discuss the first of these, levels of evidence, in terms of principles, rather than the precise standards that have evolved. The second is the distinction between efficacy, effectiveness and efficiency. Both of these issues are critical for the transfer of research into practice. The first addresses the extent to which conclusions could be determined by the context of the original research. The second addresses the issue of whether research is sufficiently mature to warrant a change in practice.

These two issues are considered in turn, firstly as they apply to the healthcare system, and then as they might apply to education-care.

Reliability in the research evidence

Fletcher and Sackett (1979) developed the concept of evidence-based practice as a systematic approach to evaluation of research and the formation of governmental policy on the yearly health check. Within this framework, each research report or evaluation is categorised in terms of the level of evidence that is inherent in the 'design' and conduct of the research, and the strength of recommendation that it would support. Five levels of evidence are normally recognized in medicine (see for example, OCEBM, 2004). These range from level 5, the lowest level of support - expert opinion, to level 1*, the highest - a meta-analysis of homogenous randomized controlled trials.

Few would suggest that these same standards of evidence can be transferred directly into education. A limited number of experiments have been conducted at level 1 (see for example, Toroyan *et al.*, 2003), but randomly controlled trials in education are difficult to construct for a range of philosophical, ethical and pragmatic reasons. Although some of the philosophical limitations might only affect the 'intellectualist' model of research (Oancea, 2005), ethical and pragmatic limitations are hard to avoid (e.g. providing additional resources, testing a 'better' model, crossover between subjects etc.). There is, anyway, a danger in treating the explicit levels of evidence, as more critical than the conceptual understanding of the issues that gave rise to them (cf. Wenger's comments on communities of practice in Wenger, 1998). Technician researchers in e-learning must still account for the same issues, whichever model of research is applied.

Levels of evidence and the management of potential bias

The seminal work that underlies the levels of evidence is almost universally attributed to Fisher's conceptual model of experimental design and analysis – magic squares, the randomised controlled design (RCT) and statistical significance (Fitz-Gibbon, 2003). Randomisation is, of course, central to the statistical analysis of outcomes against a null hypothesis.

However, randomisation has a far wider significance, even if this is often unrecognised (Imbens, 2002). As Fisher points out (1990, p. 17-21), randomisation limits the influence of unpredicted and/or unknown factors on the experiment. Level 1 (randomised controlled trials - RCT) research provides a standard for research, which removes the need for the research to be repeated within the same context. Each of the other 'levels' of evidence (levels 2, 3, 4) of experimental design can then be seen as increasing the potential for the outcomes to be confounded by factors that are external to the experiment, or an inherent part of it (see table 4 below).

Table 4: Sources of bias in different experimental settings, levels 2 to 4

2	Cohort Study	No randomisation before study: unknown factors may influence allocation to control and intervention group
3	Case-controlled study	Cases are identified 'post-hoc': data collection is subject to recollection bias; control group is matched to the intervention group; data collection may be biased towards the intervention group.
4	Case series	No control group – data biased to individual cases

The inability to conduct an RCT does not invalidate research at other levels. The difference does not lie in the validity of the results per se, but in the scope with which the results can be transferred to different, future contexts. As noted above, evidence-based practice requires that evidence, even at level 1, must be assessed for validity within the context of each particular decision.

If research in ICTE by 'technicians' is expected to feed evidence-based practice in education, then an assessment of the limitations inherent within the context and process of the research is required, unless a methodology exists that is specific to education and inapplicable to healthcare that obviates this. Only the design research methodology (Collins, 1999) (previously called a design experiment, Brown, 1992; Collins, 1992) could claim to be relevant.

This methodology attempts to marry the two modes of research that are suggested by Oancea. Learning theory informs experimental design and evaluation of experimental design provides feedback to learning theory through a series of cycles. This rejects the controlled laboratory model of scientific research in favour of collaborative development between researchers, designers and practitioners, conducted within the complexity of social and educational interactions that take place in natural learning environments (as echoed in MacFarlane, 2004). Although the cyclical development has strong parallels with action research (Laurillard, 2004; Lewin, 1946), the end point is both a well-designed but adaptable solution, and a more-refined intellectual model. The process is focused on innovation, rather than problem solving and intended to be data rich, in order to create the volume of data that is required to build complex models and to establish an archive of data for others in the wider community to access. Barab and Squire (2004) raise concerns over a methodology which confuses the role of the researcher as both designer and evaluator of that design in practice. Their recommendation is that design science should follow good practice in qualitative research in order to transfer richly contextualized knowledge to a more detailed, theoretical model. However, instances of this methodology are few and isolated.

Brown's initial design experiment (Brown, 1992) was extended with Campione into the 'Fostering a Community of Learners' for integrating groups of pupils across a number of years in primary education (Collins *et al.*, 2004, pp. 14-21). Joseph's 'Passion Curriculum' evolved over a similar length of time (Collins *et al.*, 2004, pp. 21-27) and is based within a similar mixed-age context. Other instances appear selective in the principles of design research that are followed (e.g. in language learning, Hoadley, 2002; 2004). Where practiced, design research highlights the need to distinguish the roles of designer, practitioner and researcher. It may orient some of the research outcomes towards the practitioner but it emphasizes, rather than removes, the responsibility of subsequent practitioners to assess the relevance of that work in the context of their own practice. Evolutionary design and extended testing in practice, without the ties to theoretical models, may be equally effective in providing suitable evidence for evidence-based practice (e.g. Language, Truth and Logic, Barwise & Etchemendy, 2002).

Irrespective of the model of research that is adopted, any factor that remains consistent within the research has the potential to restrict the validity of the outcomes in a different context. Similarly any conflict of interest, or loss of independence, between the researcher, the designer, and any practitioner involved in the research may restrict the range of contexts across which others might apply the outcomes. Whenever research is published as relevant to practice, it is incumbent on the researcher to acknowledge and address these factors.

Relevance to practice

The second component from Fletcher and Sackett's work is based on the distinctions described in terms of seven 'research priorities'. The distinctions between the first three will be taken into account, the remaining four are associated with issues that do not translate in the analogy that is being drawn. The first three, taken with minor adaptation from the original paper, were between efficacy, effectiveness and efficiency (1979, p. 1202):

- *Efficacy*. This area is reflected in the question: Does X lead to a better outcome *among those who follow the subsequent advice*?
- *Effectiveness*. The relevant question is: Does X benefit *those to whom it is offered*?
- *Efficiency*. The relevant question is: Is the effective maneuver [sic] being made available to those who could benefit from it with optimal use of resources?

(In the original article *X* was 'early detection of a condition or risk factor').

A second classification of similar issues is now conventional in the context of developing and testing a new drug (Jadad, 1998). Jadad identifies four phases (see Table 5 below).

Table 5: The four phases of research mapped to research priorities

Phase	Statement	Summary
1	Can a new drug be shown to have an effect?	(Effect)
2	Can a new drug be shown to have an effect within an RCT study with a selected population that takes the drug properly?	*Efficacy*
3	Can a new drug be shown to have an effect within an RCT study within a typical population that behaves normally?	*Effectiveness*
4	Are there any previously unobserved outcomes post release (case series)?	Side-effects

Although the two approaches are not identical, the similarities are clear across phases 2 and 3 (italicized) and this parallel is central to the discussion that follows. This represents a critical phase in validating the transfer from 'correct usage' to 'real life'. In phase 2 it is expected that any treatment will be applied *in the optimum conditions* in order to emphasize any potential distinction between the two experimental conditions. The conduct of the experiment will, typically, have additional resources and may well have 'committed' participants (such as those discussed in Parsons, 1974) or, in ICTE, provide little separation between the design of resources and the use of materials (cf. the definitions in Koper *et al.* (2004) of levels of reuse). These factors limit the potential to generalize results to normal practice. The key function of phase 3 research is to demonstrate that efficacy can be generalized to conventional practice. If this is a critical step in warranting a change in healthcare practice, there seems to be no justification to eliminate this in education-care practice. To ignore this must imply either that such experiments will always succeed, or that they will always fail!

For the remaining phases, the first phase would appear to be a simpler level than considered by Fletcher and Sackett (1979). On the other hand, efficiency is not explicitly represented in the four phases, although it is a key consideration in any soft-system analysis. Even if a change is effective for all participants in the system, efficiency is often assessed in distinct ways. In healthcare, efficiency for a drug company is not the same as efficiency in healthcare policy. In education-care, on-line communities may be more efficient than face-to-face discussion groups from an institutional perspective, but are not necessarily more efficient from a teacher/lecturer or learner's viewpoint.

Table 6 (below) shows the combined set, integrated into a quasi-linear scale. Alongside each one is the appropriate healthcare question, and an analogous question for education-care. Since 'efficiency' in healthcare is not included within Phases 1 to 4, the education-care questions are labelled A to E.

Table 6: Distinct research questions in healthcare and education-care

	Healthcare System	**Education-care System**
Effect:	Phase 1: Can a new drug be shown to have an effect?	Phase A: Can a new ICTE part of a course be shown to (1) have an effect (2) have an effect on learning, within a limited number of students in advantageous conditions?
Efficacy	Phase 2: Can a new drug be shown to have an effect within an RCT study with a selected population that takes the drug properly?	Phase B: Can a new ICTE part of a course be shown to have a positive effect on learning across a suitably large, selected range of students who study properly?
Effectiveness	Phase 3: Can a new drug be shown to have an effect within an RCT study within a typical population that behaves normally?	Phase C: Can a new ICTE part of a course be shown to have a positive effect on learning across a suitably large range of students where no control is maintained on how it is used?
Efficiency	The relevant question is: Is the introduction of an effective drug being made available to those who could benefit from it with optimal use of resources*?	Phase D: Does the introduction of a new effective ICTE part of a course with a limited set of resources, for a specific group of students represent the best use of resources?
Side-effects	Phase 4: What otherwise unknown side effects result from full-scale? use of a drug	Phase E: What otherwise unknown side effects result from full-scale use of a new ICTE component in a course?

What is gained?

The analogy has led us to identify two issues relating to the quality of research that could claim to justify a change in practice in ICTE. The first is the need for a proactive recognition of the limiting contextual factors in reporting research outcomes. The second is the categorisation of research into a number of phases. If a change in practice within healthcare is not warranted without a sufficient volume of contextually relevant evidence at phase 3, then the implication is that changes in practice in education-care, or more specifically in the use of ICTE in education-care, are not warranted until sufficient evidence at phase C is available. In order to clarify this, we outline the key distinctions between the first four phases in education-care. (The final phase, phase E, would be expected to follow a 'case series' model.)

In characterizing each of these phases below, the intention is to distinguish the goals, the context and the key participants within the research and to remain inclusive in terms of the research that could be classified. These definitions anticipate that the research methodologies will change from phase to phase, removing some artificial conflicts but without adopting a prescriptive view. Each description is structured as a series of constraints on the original CATWOE description complemented with two additional categories: 'D' identifies the designer(s) and 'R' identifies the active researcher(s). In each case the research outcomes are expected to be directly relevant to the transformation (T) and reflect the Weltanschauung (W). Distinctions between phases A to C are given prominence.

Proposed Definitions

Phase A can be characterized as a demonstration that some technology has a measurable effect on learners, either indirectly in terms of some behaviour that might be considered as leading to improved learning (A.1) or as measured in terms of existing learning outcomes (A.2). This work is likely to be small scale, with a restricted set of well-motivated students (e.g. within a single course module). The research is likely to be conducted by one or two self-motivated teachers/lecturers who are either the researchers/designers or are closely related to the research process. This research is expected to be conducted under 'research positive' conditions: the research is likely to be funded explicitly, or indirectly supported in terms of additional time available and/or personal commitment to establishing positive results, etc. (see table 7).

The distinction between A.1 and A.2 is made to highlight research that can demonstrate improved learning. Phase A research is dominated by the introduction of new technology (e.g. interactive video disks, hypermedia, Internet, reusable learning objects), even though, all too frequently, the educational content and the learner's experience remains unchanged. It is accepted, as one reviewer noted, that the introduction of new technology is almost certain to produce some indirect effects, but removing A.1 from the classification would exclude a considerable volume of research in ICTE that is already published.

In addition, if the practitioner is to be convinced that they should change their own practice, it is essential that the impact on learning (A.2) is established rather than presumed (or artificially created by changing the criteria by which learning is established, MacFarlane, 2004).

Table 7. Summary of research in phase A

Phase A: Effect	
C	A selected set of students (e.g., in a single course module)
A	A small set of well-motivated teachers/lecturers/technologists related to the research
T	Integration of technological components in an educational environment
W	Introducing educational technology is reliable
O	Owners provide funding to cover the costs of conducting the research and development of educational materials
E	In constrained conditions
R/D	May be/include any one (or more) of the actors

Table 8. Summary of research in phase B

Phase B: Educational efficacy	
C	A selected set of students on a number of courses
A	A small set of well-motivated teachers/lecturers/technologists
T	Introducing a specific e-learning component into a well-defined set of courses
W	The introduction of (new) e-learning, under suitable conditions, leads to an improvement in educational outcomes in a clearly-defined range of educational contexts
O	Provide additional resources to cover the costs of conducting the research and development of educational/support materials
E	A well-defined set of conditions
D/R	Should not be one of the actors

There remains an inherent risk, in research classified as phase A.2, that improved learning results from a shared understanding between the designer and actor(s), rather than from factors that are inherent in the design of the resources when used appropriately. Phase B research must address this issue and demonstrate that educational improvements can be reproduced reliably within a wider, but well-defined, educational context. This phase must be able to establish the relationship between design, good practice and educational outcomes, subject to conditions defined by a suitable set of contextual variables. Care must be taken to separate use ‘as considered appropriate by the practitioners’ in this phase from use ‘as required by the designer’, which should only be included in phase A. It is expected that the context will still be conducted in resource positive conditions, but the allocation of resources should be tracked and quantified where possible, in order to identify the conditions for use in subsequent trials where additional resources are not available (i.e., phase C). It is expected that the students will be selected from those that are most likely to take advantage of the resources that are available (see table 8).

At the end of this phase it should be rational to claim that new resources could be of benefit, across a well-defined range of contexts, as long as those who are using them are suitably motivated and/or rewarded. Successful research at phase B validates research for phase C.

Phase C must demonstrate that local ‘efficacy’ can be reproduced as effective practice once the advantages of research in earlier phases have been removed. Since the intention is to explore the reliability of the relationships that are established in phase B, it is critical that the practitioners and the students are a fully representative sample of those who would be expected to use the resource within its anticipated target context. All aspects of the design, including support materials, should be fixed at this stage. Although limited resources may well be necessary to support the research, their use should be to enhance evaluation rather than any aspect of ‘normal’ use. It is likely that the degree of educational improvement will vary to a greater extent than in phase B. Although it might be tempting to presume that minor changes in the materials will lead to further improvements, such an assumption cannot be validated without further trials (see table 9). It is more rational to recognize such variations as limitations on future use and to investigate the variation in phase D.

It is only on successful completion of research at this stage that it becomes plausible to suggest that other practitioners could replicate these outcomes in a matching context.

Table 9. Summary of research in phase C

Phase C: Educational effectiveness	
C	Typical cohorts of students selected from courses within well-defined subject areas
A	Normal teachers/lecturers/technologists, with no additional support
T	Introducing specific e-learning components into a well-defined set of courses under typical conditions
W	The introduction of e-learning is an effective approach to education
O	Provide additional funding restricted to cover the costs of evaluation
E	In a conventional setting augmented with proven technology
D	Should be neither an actor nor a researcher
R	Should be neither actor nor designer

Phase D research covers the transition from ‘effectiveness’ to efficiency and, from a systems’ perspective, must account for the separate viewpoints of all the stakeholders. The systems approach would anticipate that each of the stakeholders would seek to exploit the new resources as efficiently as possible, but that this may be to the disadvantage of other stakeholders. From this perspective, the system will never be both stable and efficient for one stakeholder, if that requires an unacceptable disadvantage to other stakeholders. By implication, research in phase D requires completion of research at phase C.

Table 10. Mapping between factors and relevant phases

Factor	**Influences**
Self-selection /required attendance	Should be addressed directly – phase C.
Individual/group	a. As group-based learning – introduced in phase A2 b. As efficiency – phase D
Repair/improve	a. In compulsory education – phase C b. In non-compulsory education – phase D

With these definitions, it is possible to return to the three factors that were identified in establishing the analogy earlier in the paper. Each of these factors may reflect a distinction between the healthcare and education-care systems, but each can be addressed within a specific phase(s) of research (see table 10). Separating relevant research into phases focuses these factors into distinct questions, rather than weakening the analogy.

Conclusion

Research in ICTE that is relevant to practice in education has been characterized as falling into five phases, where each phase addresses a distinct set of questions. It is argued that unless research at phase C – effectiveness – has been completed successfully, rational practitioners, acting on the evidence-base, should not be expected to change their practice. Demonstrating that the introduction of novel technology produces some changes in student behaviour, or researching efficiency gains from a management perspective without prior research to ensure effectiveness within the learning process, is irrelevant to evidence-based practice. Even if the research establishes efficacy in a small set of advantageously selected contexts, then adoption for use with typical students, and no additional resources, whilst of potential interest, remains unjustified.

For the technician researcher, associating a phase with each research project brings a number of advantages in addition to understanding why practitioners are justified in ignoring research at levels A, B. Suggestions that any single method of research should be paramount become illogical, or at the very least, localized to each phase. Arguments regarding the relative merit of different research methods can be replaced with consideration of the relationship between, and interdependence, of the research questions. In a similar vein, whenever research is intended to be relevant to practice, due attention should be paid to clarifying the factors that constrain or potentially confound the applicability of any outcomes (cf. BMJ Publishing Group, London; The Lancet, Elsevier, London). If a practitioner is to change their practice, then the identification of contextually relevant research is paramount. Failure to acknowledge such constraints within published research invites the evidence-based practitioner to infer that the researcher was not aware of some factors that are significant to practice.

If the research community wishes to research into the failure of practitioners to change their practice, it may first be important to ensure that the community of 'technician' researchers in ICTE changes their own practice. If this were the case, then the rational practitioner might have a contextually relevant evidence-base from which to proceed!

Final Comment

Some might still argue that it is impossible to transfer expectations from medicine to education and that the field should not aspire to such standards. For those it is perhaps sanguine to compare the standards that are now expected for research in healthcare with the assessment from Fletcher and Sackett of published research at the time:

> "Most of our recommendations have been … based on grade III evidence (professional consensus or the opinion of experts). Even evidence from cohort studies and case-controlled studies was infrequently found, and many of the reports concerned uncontrolled series and at times were just case reports. Opinion or evidence from nonexperimental studies is a much less satisfactory basis for recommendation". (1979, p. 1202)

It would be encouraging to believe that we could see the same improvements, across a similar period of time, in linking research in ICTE and practice in education!

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New and Changing Teacher Roles in Higher Education in a Digital Age

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ABSTRACT

Digital tools are increasingly being used to support teaching in higher education. These tools place new demands on the tasks and responsibilities of the teacher, and can influence teacher roles. In this study we investigate the long-term use and development of a tool for facilitating the negotiation of meaning in argumentative student texts, through teacher and peer feedback. From this setting new teacher roles have emerged.

Keywords

Teacher roles, Higher education, Communities of practice, Teaching-learning environment, Digital tools

Introduction

Teacher roles are acted out in concert with the conditions and characteristics of a *teaching-learning environment* (Entwistle, McCune & Hounsell, 2002). The conditions for teaching in higher education in Norway and elsewhere are being increasingly influenced by the use of digital tools for pedagogical purposes, and governmental strategic planning documents express high expectations about the positive effects that technology will have on teaching and learning (Norwegian Public Reports, 2000). The research reported in this paper explores the consequences of this development on teachers roles, specifically how a digital tool embedded in a context for teaching in higher education contributes to changing the conditions for teaching and the roles of the teachers.

Our study investigates a traditional disciplinary culture where a digital tool has become embedded over an extended period of time, and is now fully integrated with the teaching-learning environment. The digital tool is Kark (http://kark.uib.no/), a net-based tool for writing, feedback and discussion. Kark was developed within the Department of History at the University of Bergen (UiB) as a solution to a concrete problem, with specific pedagogical ideas in mind. The main aim was to facilitate the negotiation of meaning in argumentative student texts through teacher and peer feedback. Our approach is to view the teaching-learning environment as a community of practice.

The data presented in this study was collected at the department at the UiB for two separate research projects, the Kaleidoscope IMPACT-project (http://www.noe-kaleidoscope.org/pub/activities/activities.php?act=30) which aimed at investigating how the introduction of technology in the classroom in higher education changed the role of the teacher (Oliver, et al. 2005; Price & Oliver, this issue), and the Digital Portfolio project (Dysthe & Tolo, 2004; Dysthe & Engelsen, 2003), which aimed at investigating how digital portfolios changed the conditions of teaching and learning in higher education.

Theoretical perspective

Sociocultural perspectives on learning, which focus on knowledge and learning as social, situated, distributed, mediated and on the centrality of language (Vygotsky, 1986; Wertsch, del Rio & Alvarez, 1995) form the basis for this study. We have chosen to view the Department of History as a *community of practice* (Lave & Wenger, 1991; Wenger 1998) where there is *mutual engagement* by all the academic and administrative staff in the *joint enterprise* of teaching students the disciplinary content knowledge and acculturating them into the ways of thinking, talking and writing in the discipline (Wenger, 1998, p. 73). While students are often seen as the object of teaching, from a sociocultural perspective students are regarded as peripheral legitimate participants in the same community of practice. In this view of learning, mastery resides in the way the community of practice is organized and how the learning resources are structured. Learning is an aspect of the enculturation into the disciplinary culture (Lave, 1996). At the Department of History, Kark and the digital portfolio are the new mediating artefacts or tools (Wertsch, 1991) that are used for this purpose, in addition to the traditional cultural tools, for instance lecturing and mentoring. These tools are important elements of the *shared repertoires* (Wenger, 1998, p.82 ff) in academic disciplinary practices, as they strongly influence the changes in routines and ways of doing things in this particular teaching-learning environment. The shared repertoires are resources for the negotiation of meaning, and in academic communities of practice this negotiation, as well as its product, is very often text based. This is also the case at the department, where Kark was specifically designed as a tool to facilitate the negotiation of meaning in argumentative student texts through teacher and peer feedback.

The teacher roles are embedded in a teaching-learning environment, of which the digital tool is a partial constituent. Several interrelated aspects constitute these environments, and thus are part of the conditions for carrying out the role of the teacher. Fjuk and Ludvigsen (2001) give examples of the aspects that can be seen as forming the poles for interconnections in a distributed collaborative learning environment:

> "... theories of learning and instruction, subject domains, teacher's roles, delivery institution's educational praxis and tradition, organisational and administrative arrangements, costs, properties of ICT (information- and communication technology) and available software, geographical distances between co-learners, etc. Any changes associated with one of these aspects will inevitably *influence* and *change* the others." (Fjuk & Ludvigsen, 2001, p. 237, italics in original).

Many of these elements are relevant to the teaching-learning environment at the Department of History. Changes in teacher roles can be attributed to more than one factor, and we may expect that a change in one of the elements, for example the digital tools that are used, will also affect the teacher roles.

Research focus and methodological approach

Research focus

A preliminary version of Kark was introduced at the department in the early 1990's. Initially the tool was mainly used by the 'enthusiasts' as well as the instructors who were employed particularly to deal with the administration and development of Kark. Gradually, however, the use of Kark has had implications for the entire teaching-learning environment, has involved an increasing number of the teachers, and affected everyone employed in the department. It is therefore a suitable site for studying the teacher's role. Our overarching research question is:

How has the introduction of the digital tool Kark changed the role of the teacher in the Department of History?

In order to answer this question we focus on a number of more specific questions:

- To what extent and in which ways has the use of Kark changed the traditional practices and activities of professors and lecturers, and what new aspects are added to their work repertoire?
- To what extent has the introduction of Kark resulted in task specialisation related to individual members or groups contained in the community?
- What practices and activities do the new roles include and to what extent do they overlap or supplement the traditional teacher roles?

Methodological approach

Our theoretical perspective and the nature of our research questions calls for a qualitative approach. Data was collected from two main sources, interviews and the study of textual artefacts. We interviewed teachers (professors, lecturers and teacher assistants), the system programmer, and support staff. A semi-structured interview guide directed the interviews, which were recorded and transcribed before analysis. We also studied the tool in question - Kark.

We carried out nine interviews with seven professors and lecturers, five interviews with three administrators, and one interview with four teaching assistants. Additionally, we carried out one interview with UiB central staff, where the person was the leader of the implementation of a virtual learning environment. Quotations in the following text are numbered and coded according to the role of the interviewee and the date that the interview took place.

Having presented the theoretical perspectives that informed the study and the methods used in collecting and analysing the empirical data, we will contextualise the study by a brief description of the Norwegian higher education scene and the Department of History. Because of the crucial importance of the digital tool we have chosen to outline the historical development of Kark as well as provide a description of how it is currently being used at bachelor level. Finally we will present and discuss the findings from the empirical study in light of our theoretical perspectives.

Contextualisation of the study

Higher education in Norway after the "Quality Reform"

The recent major reform of Norwegian higher education, called the Quality Reform, was strongly influenced by the internationalization in the higher education sector in general, and the Bologna Declaration (European Higher Education Area, 1999) in particular.

Norway, although not a member of the EU, has been in the forefront of implementing the Bologna principles (Bleiklie, 2005). Formally introduced through the White Paper 27/2001, the reform is comprehensive and represents an attempt to achieve a higher degree of efficiency through devolution of authority to the higher education institutions, the provision of stronger leadership, improved pedagogy, an increased emphasis on internationalisation, and on the formation of an agency for quality assurance and accreditation (http://www.nokut.no).

The Bachelor/Master study structure (3+2 years) was implemented at all levels of Norwegian universities and colleges in autumn 2003. The new study structure represents a radical break with many of the traditions in Norwegian higher education. It affects the structure and length of undergraduate and graduate studies, our assessment system, teaching, supervision and student learning. Students now get their Bachelor's degree in 3 instead of 4 years, the new credit point system (in line with ECTS) is introduced, and our grading system has changed from a very detailed numerical scale to a letter scale (ABCDEF). All courses are modularised (most courses are 10 or 15 ETC) and the use of external assessors of undergraduate courses is reduced. A preliminary report (Michelsen & Aamodt, 2006) from the evaluation of the reform shows that it has had considerable impact on teachers and students. The new assessment forms, digital portfolios for example, have led to an increase in focus on student feedback, and an increased emphasis on passing students "through the system" more rapidly.

The Department of History, University of Bergen

The department is one of the largest in the Faculty of Arts, with 700 students - 550 at bachelor level, 150 at masters level, and 14 PhD. Students; 24 professors and associate professors; and five administrative positions.

Teaching has a high status at this department. This is not self-evident, because traditionally research has had a higher status within academia. It received "The Evaluation Award" from the government department Ministry for Church, Education and Research Affairs in 1997, for "*goal-oriented, systematic, student assessment over time*" (Ministry for Church, Education and Research affairs, 1997). Student evaluation of teaching at DH (student-feedback on courses) is driven forward by the academic staff, and not the administration, as is often the case. Our interviews with the teachers at the department reveal a genuine interest in the students' development as academics. It is not surprising that Kark was developed in this environment.

Kark – the pedagogical thrall

Kark is written in the programming language Delphi, and is implemented as a web application that runs on a server, with a web-browser user interface. Its basic functionality is to allow a user to upload a text document to a database, format it to html and make it readable to an Internet browser upon (authorised) request. It is primarily an online tool for writing and discussing, developed within the context of the department with a pedagogy of *learning through writing* in mind (Oldervoll, 1996).

Kark consists of two main tools, Kark Essay (KarkEssay) and Kark Discussion (KarkDebatt). Additionally there are a number of subserving tools often associated with learning management systems (LMS) such as resource-pages, calendar, presentation-system, dictionary, chat, evaluation tool and functionality that supports portfolio assessment. In Kark Essay (see figure 1), the teacher can give assignments (a), read texts that the students upload and give feedback on (b). Students can also comment each others work. Kark creates a log that gives the teacher version control over the students' texts and peer/teacher comments for the portfolio assessed courses. The log is available for teachers, administrators and external examiners. Kark also creates a folder in which the students can keep track of their own work.

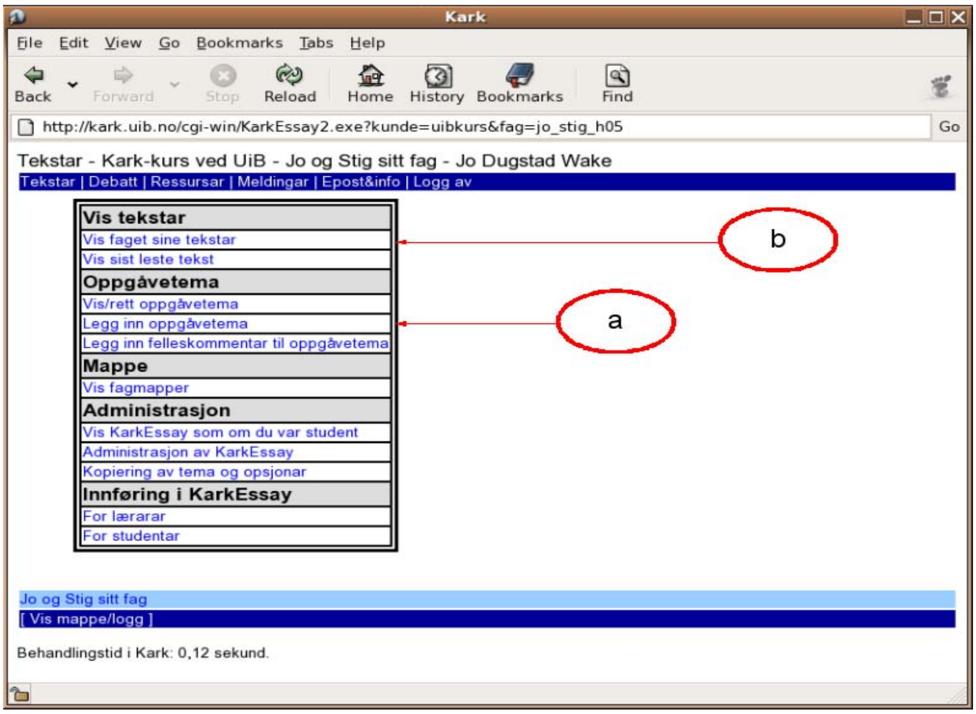

Figure 1. Administrator view of Kark Essay

Figure 2 illustrates both a teacher (a) and a student (b) commented assignment in Kark Essay. The comments appear "inside" the text, and can only be made on paragraph-level. The grey fields (c) allow the teacher or peer to display or hide comments to the text, displays the theme and version of the assignment, and who wrote it and when. The paragraph in italics (d) is resource material for the text. The following paragraph is the first paragraph in this student's text (e). The pencil icon (f) at the end of each paragraph invites the teacher to add comments to the paragraphs. Having commented on one of them, a hammer icon will appear next to it, inviting the commenter to amend the initial comment if desired.

Kark Discussion (see Figure 3) is an online discussion forum. Themes and questions raised in the lectures, or other issues of interest are discussed here by students and teachers. The teacher often takes a leading role in the discussions. This illustration only has one discussion thread, but Kark Discussion averages 2-3000 postings during a semester. It displays the discussion threads by title (a), author (b), last viewed (c), amount of replies and how many times it has been read (d).

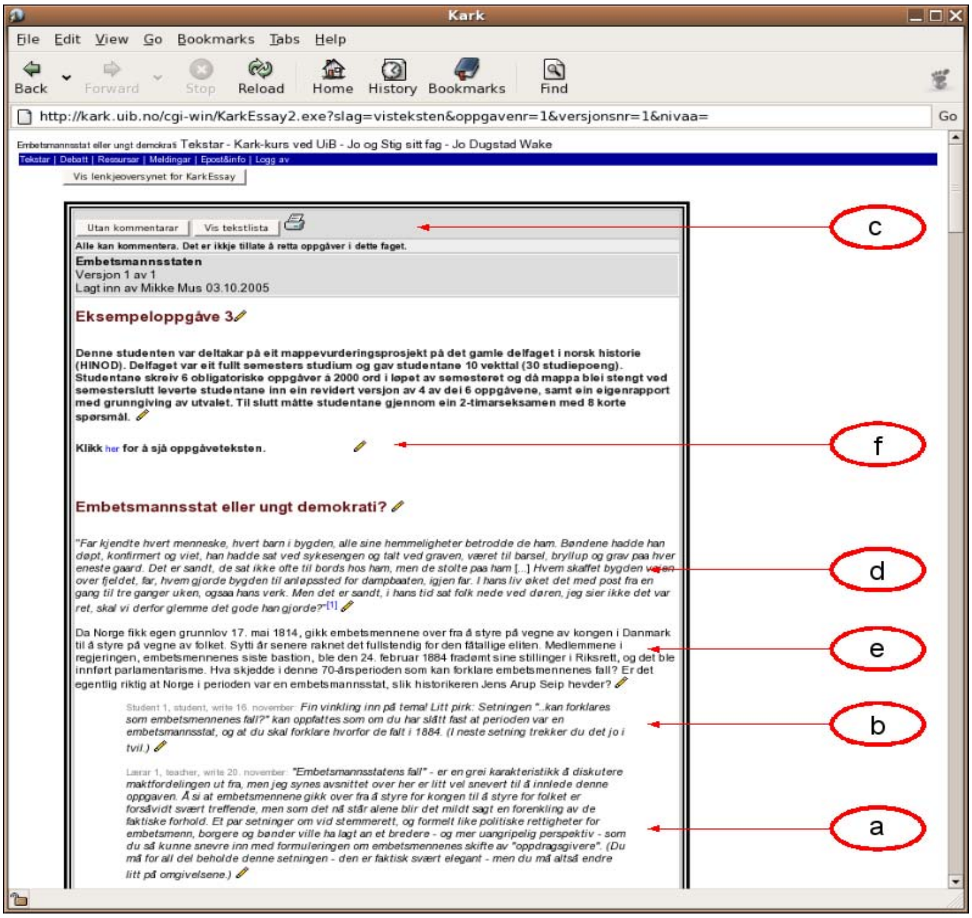

Figure 2. Commented text in Kark Essay

The Development of Kark

Kark evolved from face-to-face writing seminars for bachelor students at the department. The overarching goal was to facilitate student writing and teacher/peer feedback to an increasing number of students, based on a pedagogical conviction that the activity of writing is vital to deep learning, that is learning as critical understanding and thinking.

The main circumstance behind the development was that student numbers at the department, and UiB in general, doubled between 1987 and 1993 (Larsen, 1996), a situation that was very demanding on teaching resources, particularly the writing seminars. There was also a high exam failure rate, paving way for the common understanding that “something had to be done”. Two other circumstances were also relevant. Kark's developer had already participated in a history-specific system development project, through digitalising the results from the first Norwegian national census carried out in 1801, thus displaying both motivation for and capability of developing digital tools for scientific purposes. Also, the then named Norwegian Ministry for Church, Education and Research Affairs funded a pilot project, the Absalon-project, where the tool could be tested in the bachelor program at the department.

The two main pedagogical goals of the Absalon-project were to increase the amount of compulsory student writing, and to provide feedback on the written texts. Writing assignments was tied closely to the lectures, as the students were to compose short summaries of them. The activities included peer and teacher commentary of the summaries.

For this purpose, a simple writing tool (Absalon) was developed. Oldervoll (1996) calls it an outlining or "text-structuring tool" (p. 233). The tool generated hypertext from the students' texts. In order to facilitate sharing of the texts, the HTML-formatting tool Kark was developed. Kark stored the written texts in a database, and made it readable to a web-browser. It also stored teacher and student comments. No scientific evaluation of this particular intervention has been made available, but only one of the 200 students who took part in the project failed the exam (Oldervoll, 1996).

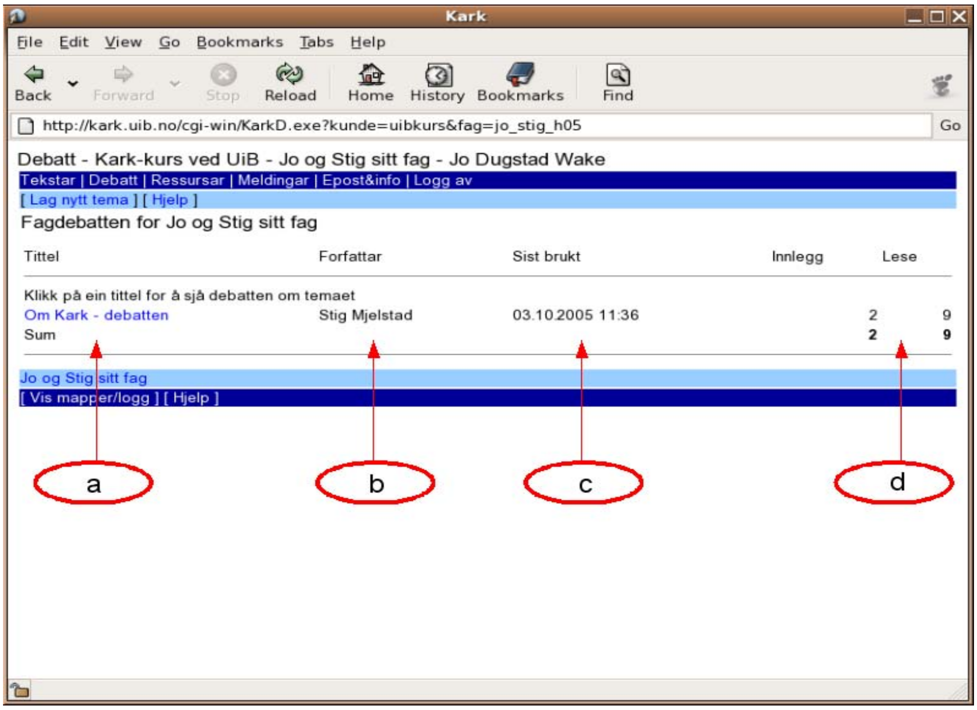

Figure 3. Kark Discussion

The experiences from the Absalon project provided a basis for the further development of the use of Kark, with its focus on writing and peer/teacher feedback of text (Oldervoll, 2003). Until 2001, it was only used as a digital continuation of the previous face-to-face writing seminars, and as a discussion forum for the individual courses. The following sections are dedicated to a description of how Kark is currently being used.

The use of Kark at Department of History

How Kark is used in the teaching at bachelor level depends on the particular course. There are two forms of assessment: traditional written exam and digital portfolio assessment. Kark is used in courses with both examination forms, but more extensively in the digital portfolio courses.

Written exam

In courses with written exams, Kark Discussion is used to facilitate a discussion that lasts throughout the semester. A broad range of topics are encouraged in order to increase student interest in participation, and teachers take a leading role in these discussions, providing topics for debate and input to the debates. Thematically, the teachers deliberately keep the discussion open in nature, as a catalyst to keep the discussion going.

Kark is also used to deliver, receive, and give feedback on a mandatory assignment early in the semester. The objective is to weed out students that do not plan to take the exam; students who do not hand in the assignment are removed from the course. Also, the Resource tool in Kark can be used for sharing lecture notes and handouts, links to web-pages and so on.

Digital portfolio assessment

Digital portfolio assessment was introduced to higher education in Norway with the "Quality Reform" (Tolo & Dysthe, 2004). Department of History tried out portfolios in 2001, and made it part of an ordinary course module in the autumn of 2002 (Oldervoll, 2003), and it is now one of two regular assessment forms at the bachelor level. Kark, with Kark Essay and version control functionality (log) already in use at this point, represented very apt means to implement the portfolio assessed courses at the department digitally, and was thus more than an indirect cause of the decision to try out digital portfolios.

Kark mediates the writing and commenting of argumentative texts in the digital portfolio assessment courses. Students write three assignments that are submitted as their portfolio at the end of the semester, and together with a small written exam they serve as the basis of assessment. The two hour written exam covers the span of the curriculum, and has mainly a control-function, to prevent students from handing in someone else's work. Each student is also required to comment on two fellow students' work. This is carried out asynchronously, and the pedagogical rationale is that students learn more when they act as teachers. Feedback from the teacher or teacher assistant is dependent on peer feedback being posted first. All comments are visible to all students registered on the course, and to all teachers at the department. The student is expected to revise, but interestingly, it is the first text version that serves as the main basis for the grading.

Findings and discussion

Overview

In this section we first describe the changes in the traditional teacher role of the professor and lecturers. While these changes are clearly identifiable, they do not fundamentally alter the teacher role – they are changes within the traditional activities and practices of a higher education teacher. We choose to call this role the *Traditional Teacher*. It is a composite role, where lecturing has been a major part together with supervision and mentoring. One of the most important findings in this study, however, is the need to differentiate the concept of the teacher in the traditional understanding of the term. As a result of the new medium and the new way the courses are structured, task specialization has become inevitable. In addition to the traditional role of the lecturer we find two new teacher roles, which we call the *Writing Mentor* and the *Orchestrator*. The primary task of the *Writing Mentor* is to give students feedback on texts, i.e. the submitted assignments in the portfolio assessed courses. The *Orchestrator* carries out a synthesis of functions; administrational, pedagogical, technological and liaison. These roles will be described more closely in the sections below, focusing on what the persons do, whether and how they are trained, how they cooperate with others in order to carry out their functions, and how the new positions have developed within the university system. We then discuss the changes in light of our theoretical perspective and concepts, particularly the importance of the different roles in utilizing the mediating functions of the digital tools and thus creating new, shared repertoires in this particular community of practice.

Changes in the traditional role of the traditional teacher

Lecturing has always been a central role of higher education teachers. The introduction of Kark and digital portfolios has not resulted in a reduction of lecturing, but has focused its purpose to provide students with historical overview and connections: "*Digital portfolios are just one aspect of the total teaching-learning system. Lectures are not redundant, on the contrary, survey lectures is a vital element*" (Extract 1, Teacher C, 03.10.05). Because the courses are now structured by portfolio assignments, there is a recognised danger of fragmented knowledge. The danger arises as the overview-giving lectures "competes" with the students' attention regarding the successive submitting of written assignments on which they are graded. Other aspects of the traditional role have gained new importance: "*Making assignments has become more important, because assignments direct student work to a considerable degree. Students immediately confront us with weaknesses or inconsistencies in formulation*" (Extract 2, Teacher D, 02.06.03). The role of Kark as an agent for change in this respect, is a matter of paving way for a new teaching method, rather than affecting the teacher role directly.

Giving feedback and guidance to students is also a traditional aspect of the teacher role, but the interviews revealed qualitative changes in the activity itself that was directly attributed to the use of Kark. The difference between face-to-face feedback and electronic feedback was a theme in the interviews: "*I have to be more careful in the way I formulate critique since I cannot elaborate on what it means in oral conversation with the student*" (Extract 3, Teacher B, 30.05.03). One of the teaching assistants (TAs), however, made an unsolicited comment during the interview that illustrates another aspect of electronic feedback: "*I tell students to mail me back if they don't understand my comments. One student e-mailed me three times in one evening, but the majority don't*" (Extract 4, TA 2, 11.05.03). The inclusion of mandatory *peer* feedback also added a new element to the teachers' feedback role. Since students had to comment on two peer texts before getting teacher comments, the teacher (and TAs) also had to read and evaluate the student feedback and decide whether or not to comment on their comments:

> "In the beginning teachers and TAs only commented on student comments when we disagreed. This was clearly a mistake and we started to acknowledge good student comments, for instance: 'Very pertinent comment- I totally agree'. This was enough to give students the assurance they needed. It may seem like a minor issue, but it actually turned out to be a very important part of our job" (Extract 5, Teacher D, 02.06.03).

The introduction of the compulsory portfolio assessment system (made possible by Kark) also resulted in a huge increase in the quantity of feedback and thus the need for TAs. This also generated a new role for the ordinary teachers as responsible for quality assurance of the work of the TAs, and the development of new forms of collaboration. This will be discussed below in connection with the role of the TAs.

New teacher roles

The Teaching Assistant as "Writing Mentor"

The new position of TAs is a direct result of the requirement of the Quality Reform to provide a closer follow-up of students. The way the role of the teaching assistants is shaped is highly contextual, and in the department is directly influenced by Kark and the digital portfolio system. In the courses that use digital portfolio assessment, all the students are given feedback on two of their written assignments. In order to manage this time consuming task, the department hires TAs whose main task is reading and commenting on the students' assignments. We label this role "Writing Mentor", because learning to write within the academic standards of the department is an essential part of the students' enculturation process.

The distinction between the TAs employed at the department and by other departments at UiB, is worth noting: while most TAs are undergraduate or master students, the department *only* employ TAs with a finished masters degree in history. This is a conscious choice in order to maintain high quality disciplinary standard and good mentoring. The TAs receive no official training in how to comment student texts, but as shown in our account of the teachers' role, some of them get on-the-job training through close collaboration with the teacher responsible for the whole course. TAs interviewed said they benefited from their experiences as masters students as well as their previous experiences with Kark. "*I learnt a lot about writing and feedback when I took my master's, particularly the "Manuscript Seminar" where master students presented part of their thesis and we took turns as opponents*" (Extract 6, TA 2, 11.05.03). This can be understood as training through modelling, and is facilitated through the open nature of the feedback system represented by Kark.

The format of the commenting does not follow a standard scheme or script, but is individual, and depends on the course context, as the following quotation shows.

> "They [the comments on portfolio assignments] are not particularly standardised. It depends on the assignments given, and the person. In addition, there is another type of assignment that is commented, that is a compulsory assignment at the very beginning of the semester. And there, the comments are standardised. That is because of the large amount [of assignments]. Our students all receive a large amount of comments, in addition to a common comment if there are general things that affect everybody" (Extract 7, Teacher G, 11.10.05).

Considerable variations in the forms and extent of the teacher-TA collaborations were reported in the interviews. One of our interviewed teachers met with her TA regularly to discuss the requirements of the portfolio assignment, how to give feedback and how to assess student essays. Another lecturer who arranged regular meetings, regarded the meetings as a training forum for the TAs. The notion of collaborating closely with other teachers in the same course in this manner, can be seen as a new aspect of the role of the traditional lecturer, and reflects that a task specialisation with respect to teaching has taken place.

The most obvious technology related change is the public nature of the comments in Kark, as all comments in all courses are available to all faculty at the department, in addition to the students in the particular courses. This could potentially be a source of pressure, at least to the lecturers that are used to a non-presence regarding colleagues when teaching, or having a role that "*previously has been hidden from insight"* (Extract 8, Teacher A, 27.05.03). Teaching through Kark made the activity more transparent, and this new openness was "*problematic for some of the lecturers"* (Extract 9, Teacher A, 14.09.05). This was also mentioned by one of the TAs: "*I was most worried about posting my written comments on the net*" (Extract 10, TA 3, 11.05.03).

However, one of the interviewed lecturers shared the task of giving feedback to students in the course 50-50% with the TA, and he described the division of labour and the nature of communication between them in a way that illustrates their interdependence:

> "Since I both deliver the lectures and the assignment texts, and... Have all the assignments that they write, naturally I am very interested in his comments. How he [the TA] comments, and that we are more or less on the same page. In that way, we are actually dependent of seeing each others comments, so that we can treat the students equally" (Extract 11, Teacher G, 11.10.05).

Extract 11 indicates a new type of collaborative teaching that that has come to the fore because of the tool that is being used.

Orchestrators

The other new role is found in the group often referred to as "Kark Support". They fulfil roles spanning from teacher, administrator, consultant, negotiator to moderator, and the operation of Kark at the department is dependent on them. Thus we call them *Orchestrators*. The role has evolved first from the increase in the significance of Kark in the teaching-learning environment at the department, and secondly from the use of Kark in other teaching-learning environments. Their importance is regarded as high, as illustrated by the quote below from the person who initiated their positions.

> "In a way, you can say that it is of crucial importance when it comes to ICT-based education, that you have someone who is willing to take the whole responsibility, and is capable of taking the whole responsibility. That is, at every department, you need a key person. If this person is not there..." (Extract 12, Teacher A, 14.09.05).

The emergence of this role is an example of task specialisation within the teaching-learning environment. The emergent nature of the Orchestrator is exemplified by how it hasn't become formalised within the university employment structure, or that the institutional conventions of UiB regarding employment didn't fit these kind of staff. Originally they were hired as administrative staff, with their positions placed under Unifob (http://www.unifob.uib.no/), a research organisation affiliated to UiB. Later, their positions were moved to the Faculty of Arts, still as administrative staff. Finally, they were hired as academic staff at the Faculty of Arts.

The constitution of this role as a whole is new, although the tasks are both overlapping and original compared to the tasks carried out by the traditional lecturers. They fulfil pedagogical functions, mainly through acting as writing mentors, but they also carry out a different set of tasks. These tasks are new elements in the shared repertoire at the department, as they gain meaning only through the presence of Kark. Examples include digitally administrative managing of students, courses and teachers in Kark, the moderating tasks of observing and managing the discussion forums for all the courses, the similar task of observing the other teachers' work, and negotiating with teachers in other departments or institutions that *need to* approach them when wanting to use Kark in their educational context. Examples of these tasks and roles are discussed in the following sections.

The orchestrators do not give lectures, but act as writing mentors in some courses. Extract 13 and 14 are comments on a question about what they do when they act as teachers.

> "Yes, then we function as teaching assistants. That is what we do, when you look at it. And we thinkit is fine to do just that. Because then we get to try out our education on ourselves" (Extract 13, Adm 2, 29.09.05).
>
> "Plus that you don't get to work with Kark [at the department] unless you are a historian. Given that, it is good to refresh our knowledge every now and then. To improve the academic activity..." (Extract 14, Adm 3, 29.09.05).

The role of acting as moderators of the discussion forums mediated by the Kark Debatt tool, is related to the role of being a teacher. The interviews reveal a stated interest in keeping the discussions going during the semester, although these are tied to the different courses. Additionally, they have the administrative role of managing courses through Kark. The following up of lecturers is an activity that they describe as "shepherding", and involves for example ensuring that the teachers keep deadlines, and that they either make course material available on the "resources" pages in Kark or forward it to them. The quotation below illustrates the relation to the lecturers, with respect to this.

> "[...] I keep myself posted on the lecturers' activities, and help them with things they wonder about.I will admit that I keep an eye on them, that they keep deadlines and such, I shepherd them a little bit. And I also prepare things for them in Kark, so that things run smoothly and so on" (Extract 15, Adm 2, 29.09.05).

This statement also reveals indications of a sense of ownership towards Kark. The sense of ownership can be found in their relation to other units that use Kark, within or outside of the UiB. For potential users of Kark, they are what Latour (1987) calls an *obligatory passage point*, which must be passed before the potential educational institution can use it. This can be called a negotiation of meaning, as the foundation for it is their understanding of the relationship between the tool and the teaching-learning environment in the two different contexts as something else than one-to-one. When discussing how an administrator or teacher new to Kark would make a selection with respect to the settings (cf. Extract 16, Adm 3, 290905), it turned out that the new user would adapt the default settings after a negotiating consultation with them:

> "Anyone that uses Kark or Classfronter [at UiB] comes here to talk to us, and then we listen to them to find out what they want to use it for. That is [issue] number one. To find out whether we think this is something that this tool can help them with or not. Or in use, at their institution. And if the answer is yes, we try to find out more about how they organise their teaching activities, and then we arrive at, in discussion with them... Or help them to arrive at the settings that would be useful to their course. And then they have sort of decided upon the default settings themselves. And then we help them, of course, by training them [in Kark] at the same time as we manipulate the initial settings. After that, they manipulate the settings themselves" (Extract 16, Adm 3, 29.09.05).

This quotation is an example of *brokeing*. According to Wenger (1998), brokering is the act of using multi-membership in communities of practice to "transfer some element of one practice into another" (Wenger, 1998, p. 109). Another example of brokering by the Orchestrators is found in the ClassFronter-project, an experiment with a commercial LMS at UiB. They were invited to participate in the project because their competencies were believed to be useful in both contexts. Another reason was that Kark Essay was integrated with ClassFronter when this particular tool was chosen to be tested at UiB, as a prerequisite by the university. In an interview with the leader of the ClassFronter-project, we discussed the training of the teachers that were to take part in this project, and how that task was later awarded to the Kark support group:

> "[initially] we trained the academic staff directly, which I found useful regarding the pilot projects. Later, Kark [the Kark support group] has taken care of the training of the academic staff, and guidance relating to the issue of pedagogical use of ICT. Because they are the ones that have, at least in the project group, competencies within this field" (Extract 17, Proj. Leader, 07.09.05).

The Orchestrator role is new with regard to the content and position, and associated with the diverse tasks of teaching, administrating, moderating, and the negotiating of meaning with external units, thus leading to an understanding of the role as an assembler of several related but diverse tasks, all tied to technology and teaching. They carry out new functions in the shared repertoire of the teaching practices of the department, and do so largely because of the integration of a new tool in the teaching-learning environment, and have come to act as brokers of the repertoire originally local to the department in other teaching-learning environments.

Conclusion

Our study revealed a complex relationship between the introduction of technology and changes to teacher roles, and the teaching-learning environment in general. Some changes are technology driven, and others can indirectly be attributed to the presence of Kark. Some changes have occurred as a consequence of introducing portfolio assessment at the department, but this teaching method would not have been implemented without the pre-existence of Kark. (Paper based portfolios was not an option.) The use of Kark as a teaching and learning tool in the department, although predating the Quality Reform, is nevertheless also strongly influenced by the restructuring of higher education, for example as a mediator in supporting large-scale feedback to students as required by the Quality Reform. While new roles have emerged, we also found stability in the activity of lecturing in this department. Giving feedback is not a new role, but the nature of the activity has changed because of the new teaching method of portfolios. While the goals remain basically the same, some of the tasks have become more genuinely a joint enterprise, primarily because Kark facilitated transparency, openness, sharing and collaboration.

We argue that one of the most crucial changes in the traditional teacher role that equally affected the TAs, was the move from private to public feedback. This was a direct result of using Kark, as all the Kark Essay-mediated comments in a course are available to the entire teaching staff at the department. Teaching in higher education has traditionally been teacher dependent and personal (Oliver et al., 2005). However, when teachers at the department were able to observe how colleagues performed their job, it opened up an unintended teacher-teacher communication. This had a number of implications, both negative and positive. However, the teacher who shared the commenting 50-50 with his TA, found the new transparency unproblematic and even emphasised his dependence on reading the TAs comments for his course in order to treat the students equally. This indicates that a division of labour has taken place, and that the reading of colleagues' comments has become a *coordination mechanism* (Malone & Crowston, 1993) for teachers who have not cooperated on a course before.

It can also be argued that the transparency of Kark and the public nature of both student and teacher writing have lead to what Wenger (1998) calls “a regime of mutual accountability”. It involves “what matters and what does not, what is important and why, [...] what to pay attention to and what to ignore, [...] when actions and artefacts are good enough and when they need improvement or refinement (ibid, p. 81). Wenger notes that such a regime plays a central role in defining the circumstances under which, as a community and as individuals, members feel concerned or unconcerned by what they are doing. We do not have evidence of this, but it is likely that teachers as well as TAs who use Kark at the department will develop a degree of expertise in giving feedback and thus strengthen this aspect of their professional role. The orchestrators enhance this development, first because they take on the administrative burden of the digital tools, and second because they act as boundary persons between all participants in the system.

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Academic Use of Digital Resources: Disciplinary Differences and the Issue of Progression revisited

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ABSTRACT

This paper examines the use of digital resources by academic staff in a single UK University and its influence on academic practice over a two to three year period. The paper describes two linked studies that address several of the themes regarding the impact of electronic resources identified in this special edition. In particular it provides findings that contribute to our understanding of changing roles and practices in academic teaching (Oliver this edition). The themes explored in this paper include the way disciplinary differences affect the use of digital resources, and how academic progression is understood by academic staff in different disciplines, and its role in informing staff choices in deploying digital resources for student use. The paper also addresses the issue of changing academic practice and the adoption life cycle in relation to use of digital resources.

Keywords

Digital resources, Disciplinary differences, Teaching and learning, Distributed learning environments

Introduction

The explosive growth of the Internet and the Web has led to a growth in speculation about the ways in which networked and e-learning will affect academic practices and the university as an institution (Steeples and Jones, 2002; Brown and Duguid, 2000). Increasingly researchers have become aware of the ways the university and the practices of university staff can resist such changes and provide a 'resourceful constraint' to the changes surrounding the introduction of networked learning (Cuban, 2001; Brown and Duguid, 2000; Cornford, 2002). Within this changing environment the take-up and use of digital resources by academic staff will be a critical factor in the success of attempts to integrate networked technologies into university teaching. There has been little research work to date that investigates the ways in which academic practice varies in relation to digital resources although there is a significant tradition of research concerned more broadly with disciplinary differences amongst academics. Two key issues are identified. Different discipline and subject areas show significant divergence in the types and uses of digital resources and academic progression seems to affect the use of resources within the different disciplines. The research supports the view that disciplinary and subject differences reported in other contexts have a significant influence in relation to the use of digital resources.

This paper reports findings from two independent but linked studies. The first study took place in 2002/2003, and was conducted in the context of a broad formative evaluation of the Joint Information Systems Committee (JISC)-Distributed National Electronic Resource (DNER http://www.cerlim.ac.uk/edner/welcome.html), now known as the Information Environment. The second phase took place in 2005, and was conducted under the aegis of a European network of excellence, Kaleidoscope, as part of the project *The impact of technology-enhanced learning on roles and practices in higher education* (Oliver et al., 2005)

The earlier research was based on interviews conducted with academic staff at a single University who had been identified as making significant use of digital resources in their teaching, and has been reported in two conference papers (Jones et al., 2003; Jones et al., 2004). The focus for this first stage of research was an evaluation of a large-scale national programme intended to supply digital resources for use in Higher Education. The policy assumptions that informed the projects in this programme have been reported elsewhere (Goodyear and Jones, 2003). The results of the first phase research were a set of categories describing the variation in how academics perceived digital resources used for teaching and learning and an assessment of the disciplinary and subject differences in the ways that digital resources were used.

The second study added a longitudinal element to the original research by returning to some of the staff interviewed for the earlier work and re-interviewing them about the changes that had taken place since the original interview. Our principal consideration was whether since the first study there had been a move toward mainstream activity in the use of digital resources for teaching and learning. We examined the ways in which academic approaches to the use of digital resources have changed over the past two or more years and the ways in which the academic experience of digital resources had altered. The research also touches upon the policy push in this area and the ways in which technology is impacting on practice and the ways academic engagement with technology is related to approaches to teaching.

Disciplinary differences

Previous research has identified disciplinary differences as a significant influence on the ways in which academic work is organized (Becher 1990; 1994; Neumann, 2001; Becher and Trowler, 2001). Disciplines have been shown to influence the relationship of academics to knowledge, the relationship of students at undergraduate and post-graduate levels to teaching staff and the type of knowledge that students are expected to gain about their subject or discipline area. Discipline and subject differences have also been taken into account by the relational tradition of research, which assumes that disciplines are a contextual influence affecting teaching and learning (for a summary of this research see Prosser and Trigwell, 1999).

Research investigating disciplinary differences has not been fully developed to explore whether such disciplinary and subject differences affect the ways in which digital resources are conceptualized and used, or whether disciplinary differences combine with student academic progression to affect staff and student use of digital resources.

The research related to disciplines simplifies academic practice in a variety of clusters or groupings. Becher (1994), for example, uses a four-fold taxonomy.

Table 1. Knowledge and Disciplinary Groups (adapted from Becher 1994)

Disciplinary Groupings	Nature of knowledge
Pure Sciences (e.g. Physics) “Hard Pure”	Cumulative; atomistic (crystalline/tree-like) concerned with universals, quantities, simplification; resulting in discovery/explanation
Humanities (e.g. history) and pure social sciences (e.g. anthropology) “Soft Pure”	Reiterative; holistic (organic/river like); concerned with particulars, qualities, complication; resulting in understanding/interpretation.
Technologies (e.g. mechanical engineering) “Hard Applied”	Purposive, pragmatic, (know-how via hard knowledge); concerned with mastery of physical environment; resulting in products/techniques.
Applied social sciences (e.g. education); “Soft Applied”	Functional; utilitarian (know-how via soft knowledge); concerned with enhancement of [semi] professional practice; resulting in protocols procedures.

For practical and policy purposes subjects and disciplines have also been divided up in a variety of ways, for example The Learning and Teaching Support Network, a part of the Higher Education Academy in the UK has 24 different subject centres. The detail of these divisions does not concern us here but the boundary of a discipline or subject is not easily described: as Becher has noted, disciplines themselves are composed of a “constantly changing kaleidoscope of smaller components” (1990, p.333).

The studies

The first phase of research was conducted at a single university in the North West of England. The university was a regional research and teaching institution. Nineteen academics were interviewed across a range of disciplines. The interviews did not attempt to be representative of current academic practice, but to illuminate the issues that might have a bearing on how academics currently approach the use of digital resources. The nineteen members of staff had been identified as advanced users of digital resources in their teaching by either the relevant subject librarian or the learning and technology central support team, in many cases by both. The aim of the research was to identify the conceptions of digital resources held by advanced users of digital technologies for teaching and learning.

In the second phase we re-contacted the original 19 interviewees to try to arrange a second interview and we were successful in obtaining nine interviews with original participants. There were some inevitable losses from the original interviewees as some had changed jobs, left the institution or changed their role within the institution. Of those contacted, but not interviewed, one had left and four had changed role. Of those who had changed role they had either moved to a research-only role or taken a managerial role and were no longer involved in teaching. The remaining (5) either declined to participate or could not be contacted during the period of the study.

At the time of the initial research the large-scale use of digital resources for teaching was limited and relatively recent. Returning to staff who had been identified as advanced users at the stage of early adoption might provide some interesting clues to:

- the ways in which academic practice has altered with the increasing supply of digital resources
- changes to the academic experience of using digital resources
- the move into more mainstream institutional support of academic use of digital resources by libraries and central support staff.

Method

Overall the research adopted a broadly phenomenographic approach and aimed to build upon earlier work in that tradition concerned with academic staff and their approach to digital resources (McDowell, 2002) and teachers' conceptions of teaching (Prosser and Trigwell, 1999). The methods were centred on interviews with an element of stimulated recall to focus the interview on specific phenomena rather than general opinions. Stimulated recall in this context meant that staff were interviewed in their own office with access to a networked computer. The interviewees were encouraged to make use of available documentation, display the digital resources they used and to access the courses in which they used digital resources. The interviews were conversational in style and began with a request from the interviewer for the member of staff to describe their personal use of digital resources in their teaching.

> Interviewer: So if you could just start by telling me a little bit about your teaching and what you use, what sort of digital resources you might use?

The interview continued with the interviewer asking the respondent to amplify and clarify areas of interest that had already been addressed by the respondent rather than using any kind of schedule. The interviews were conducted in the member of staff's own office and a computer was always available. The availability of the computer allowed the member of staff to show relevant resources including departmental, course and personal areas that they used for teaching purposes. A section of the interview towards the end was reserved to allow the interviewer to show a number of relevant sites to the interviewee. The interviews were varied in length but lasted between 30 minutes and 1 hour in all cases. The interviews were later transcribed, analyzed and coded using an iterative approach to generating categories of description.

Results

Themes from the research

This section examines issues that arose from an analysis of the rich data contained in the interviews. The section contains data from the two phases but it is organised according to themes that emerged during the first phase of research.

Disciplinary and subject approaches

The interviews suggest that the use of digital resources is significantly related to the subject and discipline area being taught. However the picture is complex and seems to be affected by a number of cross cutting pressures. In the account that follows we will try to represent this complexity by taking a number of different influences and indicating how these different pressures organise into disciplinary and subject patterns.

The complex picture can be simplified into two main types of use related to subject and discipline (Jones et al., 2004).

In Physics, Engineering and Mathematics the use of digital resources was closely related to the use of specialist software. In all cases the staff in these subjects expressed an interest in the use of images, including moving and 3D images and simulations. This was particularly so in the case of Biological Sciences. Mathematics and science based subjects more generally were also distinct in that they did not direct students toward journal use of any kind until the final stages of an undergraduate programme whereas social science and arts students were more likely to be directed toward journals and e-journals throughout their degree.

In social sciences such as Politics, Languages and Applied Social Sciences the staff interviewed were most interested in the use of particular types of Web based materials. These subjects needed access to the most current up-to-date material often from Government or specific agency sites. Some of the humanities such as Languages were also interested in access to news media such as local language newspapers.

All of the interviewees in these subjects expressed an interest in using digital searches for materials that could be accessed either digitally or using traditional methods but History and Law stood out as subject areas that most emphasised this type of use and had large databases of non-copyright material available for teaching. This contrasted with music, which was constrained from using the large amounts of available digital material for teaching by copyright restrictions.

This broad disciplinary pattern appears to be related to core aspects of the type of knowledge students are being introduced to. In many natural science based subjects mathematics was a core competence.

> " …personally I make fairly extensive use of certain mathematical packages which I use for my teaching.." (Physics lecturer)

Interviewees in these subjects also suggested that students were engaged in mastering a relatively stable and accepted taught canon in their studies and consequently they could use materials from text book sites.

> "quite a few of them are links to text book websites where there might be animations or other resources, there are also some sites that are based on structural databases so there are some databases of protein structures so if we are going through talking about DNA binding proteins you can click to a link that is one of these 3D structure databases." (Biology lecturer)

The ability to make use of standard commercially supplied materials was also present in subject areas such as Law, which had large amounts of resources available in digital form.

> "..one of the main digital resources in Law and this is generally the case and not just on my courses, is on-line databases of reported cases and unreported cases but they tend to be from commercial providers.." (Law lecturer)

On the other hand many of the social science and humanities based lecturers placed an emphasis on the ability of their students to assess different approaches and engage in discussion of the relative merits of what could be fundamentally different ways of seeing a single subject or disciplinary area. Another requirement, mainly in the social sciences but including a language lecturer, was for up-to-date materials for their teaching.

> " I mean, things in Spanish change very, very rapidly and what we teach from year to year sort of changes as well" (Language lecturer)

> " we are encouraging students to look at, to look in detail at what is going on in contemporary conflicts …. if it was the Kosovan conflict we would encourage them to look at what the Foreign Offices view is, what the Russians view is, what the American view is and you often can't do that

from resources in the Library because they are bound to be several years out of date" (Politics lecturer)

Some of these subjects did not have an agreed and stable canon for teaching, or rather if there was one it was based on the application of agreed principles and academic practices to current issues. These issues were also ones that, at times, courted controversy and were not of the kind that could be easily set out in a standard text.

> "The other thing I encourage students to look at which I think that the web becomes particularly useful for is websites that have been put up by people who are wanting to write their personal experience of illness because then they are getting perspectives that are different to what would be presented in the sort of academic press or just general news and that, I mean that was when I mentioned anorexia last year, there was quite a wide range of sites which were called, which came under a heading of "PRO-ANA" and these were sites put up by people with anorexia advising other anorexics on how to diet." (Social Science lecturer)

In languages similar issues arose in terms of the content of web resources that students accessed:

> "..to take an extreme example, Spain still has a fairly restrictive Abortion Law so if they are doing a project on Spanish Abortion Law then they would come across obviously extremist groups, they come across Catholic groups, they come across Government web pages, so it is just, I suppose, teaching them to identify or making it clear that they have to identify the source of the information and from that to actually say 'ok well this is a Catholic group, the Catholic obviously have, they have this particular stand point on abortion, therefore the information I am getting is liable to be biased in that particular way'" (Language lecturer)

A concern for all lecturers who used external resources was the persistence of links. A common strategy was to recommend materials held on relatively reliable sites, such as government web sites and the sites maintained by large businesses, charities and NGOs. Despite the use of reliable source sites a major issue for some lecturers remained the continuity of links. The following example is of a lecturer who in the first phase reported pointing to links who has begun to bring documents into the University VLE in order to ensure secure access:

> "…if there are documents that are usually, usually sort of on the Department of Health website that are relating to the Social Work course then I'll quite often take them off and put them on the noticeboard so that they're easy for the students to access" […....]
>
> "...I mean it's felt for me- like that's a way of er making it a little bit safer, some of those documents might change, they may move sites, may move address …" (Applied Social Science lecturer) "

This finding that the problem has persisted over two years, is significant in that it points to a need for more secure management of certain digital resources especially 'ephemera'.

Progression

In the first phase of research all academic staff in all subject areas reported some degree of progression in the use of networked digital resources related to academic progression. The involvement of staff in teaching at first year undergraduate level varied but all interviewees reported some student use of digital resources from the first year. However even when all students were introduced to digital resources in their first year it was students in their final year or sometimes their penultimate year of study that made the most significant use of digital resources.

> a) Interviewer: So that is the historical abstract
> History lecturer: Yes. So we use this a lot. Students are introduced to this in the first year but I don't think they need it at that stage but I use all of this in the third year.
>
> b) Interviewer: Would you direct students to e-journals?
> Engineering tutor: It would depend on the member of staff, we don't do a lot of teaching by e-journals, that is more when you get on to the fourth year teaching and research where we will propose further material. *(Fourth year in this context is registration for a Masters in Engineering following directly on from three years of undergraduate work.)*

Staff also clearly differentiated between an introduction, often described in terms of basic information skills and sometimes left to librarians, and higher order research-like skills that were developed in the final undergraduate years or at postgraduate level. In some subject areas such as mathematics and sciences the use of journals and e-journals was largely reserved for final years students or postgraduates.

It was notable however that the availability of journal articles had changed significantly between the two phases:

> "If students are doing projects they start to use the Library more and in the third year they start to use catalogues much more… but the actual electronic journals and electronic searching … I think they will be reading more beginning the post-graduate level." (Mathematics lecturer: phase 1)

Mathematical journals, amongst others, had been digitized and collected over most of the twentieth century. Use was still largely at post-graduate level, though this was changing for reasons connected to the provision of an historic archive of articles, and the library was now systematically involved in the subscription based supply of an extensive archive of journal articles. This was thought to be important because of specific disciplinary conditions:

> "I mean mathematical papers do tend to have a very long shelf-life, especially the better ones and beginning students tend to read the old papers before they read the new ones." (Mathematics lecturer: phase 2)

The second phase of interviews showed that there had been significant developments in the availability of resources and the way they were used in the different year groups. Another subject that stood out in this regard was History. In the first two years journal articles were noted to be important but by the third year the focus was moving to the availability and use of digital primary resources.

> "Now essentially I think the first year students are going to be using access to printed materials like JSTOR, and probably that's true of largely second year students as well, but once they move into the third year and they're doing primary research, their own dissertation, and post-grad work thereafter, then the digital resources would become invaluable." (History lecturer)

[JSTOR non-profit digital archive of scholarly journals: http://www.jstor.org/]

In both Mathematics and History the use of digital resources had been affected by the increasing supply of a wide range of materials.

The view of progression in the use of digital resources provided by academic staff may have been influenced by the main teaching load of the member of staff. Teaching staff with more responsibility for first year students were more likely to mention skills training as an issue, whereas staff concentrating on final year students were less concerned with general skills but had an awareness of the students' need for highly specific resources. These findings are consistent with research conducted in the Open University, in which students at lower levels experienced difficulties due to skills deficits despite course guidance in information skills, whereas postgraduate students were reported to have more fully developed skills on entry (MacDonald et al., 2001). The most notable change reported by academic staff in the use of electronic resources was when students were undertaking projects and it was at this point in undergraduate programmes that they were also encouraged to make use of digital resources in particular e-journals and digital searching for additional materials.

The teaching focus shifted from information literacy to a tendency to concentrate on teaching research skills in the final year. Participants in our second phase report that while basic skills are still taught new students have increasingly sophisticated skills. This process of change amongst student cohorts led one lecturer to comment on a general tendency for new students to have all the basic skills whilst postgraduates have more problems:

> …and the undergrads these days are actually doing a lot more. I mean they - the post-grads still have a little bit of problem, but the undergrads, I mean, on social work in particular we have students who are supposed to have the ECDL in order to graduate, and when we looked at erm the qualifications that they have in IT I'd say more than well, over, well over 50% of our undergraduates now come with erm something like, er, GCSE in Information Technology. (Applied Social Science lecturer)

Experiences of the digital resource adoption life-cycle

In the second phase of research our academic sources were mature users, and there appears to be a life-cycle in academic use of digital resources. Our first phase selection of lecturers can be understood in terms of the Technology

Adoption Life Cycle as ‘early adopters’ (Rogers, 1995). In the time between the two phases of research one department had adopted a VLE across the department and the ‘early adopter’ found himself needing to learn a new set of skills and he felt he was being overtaken by the technology.

> “I used to have responsibility for upkeep of the department website but since it's changed I just find the - I I haven't got the inclination to erm learn a new set of software um, to do things in a different way, so the kind of sort of new DreamWeaver, website management,[…....] I haven't, I don't feel in any way motivated to learn to do it all again, even though I know it's better.” (Applied Social Science lecturer)

This change coincided with his appointment to the position of head of department, and it is clear that these changes in his work role interacted with changes in deployed technologies.

In another example an engineering lecturer talks about the departmental intranet he runs:

> “I'm [intranet manager] because I started it. There's not the same amount of time or input required any more to what there used to be when I first started with it. So the system has now stabilised and I think in some ways that's maybe one of the reasons why I'm reluctant to look at changing it or going to a different system because there might be an overhead again with the set up and getting things running....” (Engineering lecturer)

Other participants who were early adopters are now in a stable situation having adjusted to the use of digital resources with no major changes expected. These cases may point to a ratchet or lockstep approach to change in which lecturing staff make significant changes but then settle into a new routine. Some staff when asked about change reported a perceived stability for example:

> “Not a great deal to be honest with you er, in other words we're still using the resources that were provided by the the unit, umm, I think that OK we experimented with a couple of other things, mainly videos online...” (Marketing lecturer)

These examples contrast with the idea of a technological ‘revolution’ and some approaches to change management that imply a continuous or smooth change process moving in one direction. Instead our findings suggest that many staff are concerned with achieving a stable state, with periods of change activity followed by plateaus or even a stepping back from technological change. This finding of discontinuous change, liable to periods of stability or reversal is an area that warrants further research as it may have significant practical implications.

Conclusions

This paper confirms the view that discipline and subject area is a significant factor affecting the use of digital resources in teaching and learning in Higher Education. These findings touch on a large volume of work concerned with subject and disciplinary differences in teaching. For example Becher and Trowler, (2001) comment that:

> " the ways in which particular groups of academics organise their professional lives are related in important ways to the intellectual tasks on which they are engaged." (p23).

Unsurprisingly perhaps this subject and task differentiation appears to carry over into the use of digital resources for teaching and learning.

In particular there appear to exist disciplinary differences in the way that digital resources are being integrated into teaching and learning within the disciplines. A strategy for the development of digital resources will need to take account of these variations and the variation that also exists in terms of level of study.

However our evidence suggests that the factors affecting this variation may not be quite the same as in other areas of disciplinary difference. The grouping of disciplines does not fully conform to the type of taxonomy that has been used to discuss disciplines more generally. The divide between hard and soft disciplines does seem to remain. It is the hard subject areas such as physics and engineering that display a distinctly different relationship to digital resources based on the need for mathematical skills and mastery of a canon within these subjects. The soft disciplines vary widely but arts, humanities and social sciences differ most notably from the hard sciences rather than with each other. The division between pure and applied subjects is not so clearly in evidence in relation to digital resources.

Issues of progression were evident in the use of digital resources in all discipline and subject areas. In the early years of study staff were interested in developing information skills among students. These differed in relation to discipline and science subjects were particularly interested in students making use of particular kinds of software for their work. In social sciences and humanities the students were introduced to a variety of materials, some of which were intended to show weaknesses or viewpoints not available in academic texts or validated resources. This use of resources was to help students learn how to assess different sources of information. These progression-related disciplinary differences touch upon the divergent ways different disciplines and subjects constitute knowledge. This was also evident in the students' use of electronic journals. Journal use of all types was not a central feature of undergraduate science subjects. In the arts, humanities and social sciences access to journals and e-journals in particular is being encouraged from the first year of undergraduate study. This is an area that shows significant change over the period of the two studies. The increased availability of digital resources in primary and secondary forms has clearly impacted on the usefulness of these resources at all levels of teaching.

The findings we have reported suggests a possible link to the theory of punctuated equilibrium in evolutionary biology and the way this theory has been used to explain technological change (Loch and Huberman, 1999). However this theory is primarily concerned with periods of stability and abrupt revolutionary change. In practical terms this approach to change can generate advice to managers on ways to advance or slow down the adoption of technology. Our findings suggest an ebbing and flowing of staff interest and engagement with change that is connected to the rapid and continuous nature of technological change. Engagement with one technology appears to be no guarantee that the next wave of technology will either be of interest or easier to master. This finding might be of interest for staff developers as it may suggest an iterative process that requires the identification of those staff most engaged with change at each point in time rather than once and for all interventions.

Cornford and Pollock (2002) following Brown and Duguid (2000) describe the university as a resourceful constraint. This study of subject and disciplinary variation indicates that the university's organisation of knowledge into discipline and subject areas influences the use of digital resources. The socio-cultural form of each subject or discipline has a history and a pattern of engagement with academic resources in teaching and learning. These ways of using resources carry over into the digital world. The study also shows a discontinuous pattern of change that may be an important issue for those involved in staff development.

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Guldberg, K., & Pilkington, R. (2007). Tutor roles in Facilitating Reflection on Practice Through Online Discussion. *Educational Technology & Society*, 10 (1), 61-72.

Tutor roles in Facilitating Reflection on Practice Through Online Discussion

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ABSTRACT

This paper is concerned with teaching and learning in a blended e-learning course that supports students in reflecting on and transforming their practice. In this paper we focus on two key aspects of the online learning environment: (i) the selection of the topic of discussion (the discussion question) by the tutor and how this influences the quality of the discussion; (ii) the interventions of the tutor within the online discussion. The aim is to understand why some online discussions 'take off'' in terms of numbers of postings and quality of engagement whilst others are less successful. Our findings show that the nature of the question impacts on discussion outcomes and that it is therefore important for tutors to pose a range of different types of questions to students in line with learning objectives. If the tutor structures discussion and chooses questions carefully there may be less need to intervene to stimulate discussion or keep it on track than is sometimes assumed. This shifts the role of the tutor somewhat toward more preparatory and plenary work with less tutor participation required to support the development of discussion skills amongst students, particularly during later stages of the course.

Keywords

Tutor Roles, E-moderation, Dialogue and learning, Online discussion groups

Introduction

From a socio-cultural perspective, talk is a key foundation of learning; language and thought are closely bound up with one another and both cognitive and affective development are strongly influenced by opportunities to talk. Vygotsky himself (1978) viewed children's development as a dialectical process involving interaction between the natural and social world and language as being essential in this process. This socio cultural view of learning extends to adult learning where research supports the view that dialogue is important and that the learning experience is enhanced when students regularly participate in discussion (Kolb, 1984; Laurillard, 2002). There is much research focusing on how encouragement of discussion and collaboration in education increases student involvement, engages students more in the learning process, and promotes student achievement and satisfaction (Clark, 2001; Hung & Chen, 2001; Garrison & Anderson 2003; McConnell 1994). For many distance-learning courses, overcoming distance is a real challenge, and well-managed learning conversations are therefore also considered an important tool for strengthening relationships between students (Jones, 2004; Laurillard 2002).

The research literature is clear, however, on the fact that merely forming a discussion group and providing the technology will not lead to learning. There are a number of variables and factors that contribute to whether any teaching and learning environment leads to learning (Salmon 2000; Laurillard 2002). The composition of the group and the roles participants undertake in the group affect the effectiveness of discussion (Guldberg & Pilkington, 2006). Opportunities for alternate forms of interaction such as time to work on task and time to develop online relationships are also important (McConnell, 1994). The nature of the tasks and/or discussion questions themselves, including the preparedness of students for undertaking tasks and their assigned discussion roles also need consideration (Salmon 2002; Desanctis & Gallupe 1987). All three are central to achieving learning objectives.

In relation to the choice of task, researchers have found that the nature and specificity of the task influences the kinds of interaction or collaboration that takes place, in turn affecting outcomes (Henri 1992). Studies have also shown that students of all ages learn better when they have a sense of engagement in or ownership of the learning task (Schön, 1983). Yet, however important the task is, there seems to be consensus that, social as well as cognitive interaction with both instructors and peers is also important in enhancing active participation and learning (Gibson et al. 2006; McConnell, 1994). It has been argued that the social climate can also have an effect on motivation, levels of confidence and hence engagement (McConnell, 1994).

Research from other sources has shown that when attempting to create an effective discourse community in a networked learning context it helps to structure debate. Discussion is also likely to be more productive when someone monitors discussion, facilitates interaction and summarises outcomes (Berzsenyi, 1999; Veerman, Andriessen & Kanselaar, 2000; Goodyear, 2001). A key concern in enabling learning to take place is therefore the role of the tutor and the balance between teacher and student participation. Research has highlighted that the role of the tutor in the online environment needs to be one in which the conditions for friendly and constructive debate are nurtured by establishing ground rules for collaboration and encouraging students to participate and adopt for themselves roles that they may at first think are the tutor's responsibility (Salmon 2002; Pilkington, 2003; Pilkington & Walker, 2003; Pilkington & Kuminek, 2004). The facilitation problem then becomes one of monitoring discussion and intervening to ensure meaningful outcomes without inhibiting discussion. There are some roles which even students in Higher Education still attribute to the tutor and may be reluctant to take on themselves, particularly when the tutor is present. Such roles include making sure the focus or direction of the discussion is maintained within the timeframe of the discussion in ways that ensure all the elements of the task or question are addressed (managing the task). Students can also be reluctant to engage in directly questioning or challenging another student's point of view and may regard the kinds of feedback comment which validate or critique other students' contributions as the tutor's job (Pilkington, 2003).

Although it is possible for teachers to model effective dialogic techniques, active teacher participation can also limit the kinds of contribution students make and their opportunity to develop ownership of discussion-management and constructive critiquing roles (Mercer, 1995; Pilkington & Walker, 2003). Reasons for this are not fully understood but in addition to reluctance to take the (perceived) role of the tutor there may also be a fear of exposing a lack of knowledge in front of the teacher. However much this is counteracted at tertiary/ adult levels, by increasing student confidence and autonomy, the effect may still be real.

Further research is needed in order to determine how the role of the tutor influences discussion and to gain further insight into what factors contribute to creating positive environments for online interaction. We aim to contribute by focusing our research on the extent to which the topic of discussion and the role of the tutor influence the nature of discussion. The aim is to understand why some discussions 'take off'' in terms of numbers of postings and quality of engagement whilst others are less successful.

Research Design and Methodology

The research described in this paper is part of a larger case study. The case study is an observation of real life events that are not controlled (Yin, 1991) with the central characteristic being that it concentrates on a particular case studied in its own right in a specified social or physical setting (Robson, 1993). In this study, the case study is the University Certificate (ASD) course, its learning environment, students and teachers. The course has a large number of students who are studying at undergraduate level (a cohort of 265 per year). These are non-traditional students who are studying by distance, part time. Most are working full-time whilst studying, or are parents caring for a child or adult with an Autism Spectrum Disorder (ASD). The course philosophy advocates an eclectic approach to theory and practice when working with the person with an ASD and also seeks to develop students' abilities in teamwork, problem solving and observation. The particular case study was selected in part due to some unique properties relevant to investigating the development of community of practice amongst learners (Lave & Wenger 1999), with course aims aligning authentically with the phenomena we wanted to study - learning to become a community of reflective practitioners.

We emphasise the unique learning environment available for us to research here. The rich teaching and learning environment combines online presentations and discussion through WebCT (the institution's Virtual Learning Environment) with CD ROM audio and visual material as well as printed module readers. Students are divided into regional tutor groups run by a local tutor with approximately 10 students per group. Students participate in face-to-face discussions with the regional tutor and each other, but also participate in online discussions. The two geographical tutor groups combine to make one online group. All online groups have similar numbers of students in them, ranging between 15 and 20 students per online group. Two tutors work together in each online group to facilitate debate and discussion and also to help support one another. Due to the high number of students on the course, there are 13 online groups in total. All these 13 online groups discuss the same questions on the bulletin boards at the same time but within their separate online groups.

The collaborative online small-group discussions are integrated with the wider online, CD ROM and other teaching resources. The pedagogic aims of these regular discussions are to create a student centred learning environment with a focus on collaboration, communication and active learning. The regional tutor has a unique role here in taking a non- interventionist approach, mainly introducing and summarising discussion and only intervening when there is a perceived specific need. The role of the tutor is to welcome and support students, particularly in the beginning stages but then, to encourage students to engage in dialogue with each other. Each discussion is open for two weeks and at the end of the two weeks the tutor summarises the discussion and signals to students that it is time to move on.

Previous research in relation to this case study has focused on in-depth qualitative analysis of the discussion transcripts of the tutorial group having the modal number of postings to the bulletin board (Guldberg & Pilkington, 2006). Emergent themes included how students belonged to a community of practice in which commonalities and differences were established between group members as part of a process of developing group identity; conversation as a source of empathy and support; the exploration of alternative and contentious viewpoints and their degree of resolution and development of common group values. Further themes included the notion of overlapping communities of practice and the use of the online conversation to mediate in renegotiating roles and practices in boundary communities such as the family, school and workplace.

In the current and ongoing stage of research we are extending previous analysis to compare data from the mode group with data from the lowest and highest posting groups. We chose a sample of bulletin board discussions from those three groups with the view to combining quantitative and qualitative analysis of the data. The sample for this research was six separate bulletin board discussions over a period of six months in the three different online groups, resulting in a total of eighteen bulletin board discussions. To give a sense of the size of the sample it amounted to a total of 408 bulletin board postings, with a corpus of 70,422 words. Group A was the lowest posting group with 78 postings. Group B was the mode group with 135 postings and Group C was the highest posting group with 195 postings. Each discussion took place with three weeks between each other.

In determining our coding framework, we first focused upon identification of themes to aid the organisation, management and understanding of the text data. The goal was to work with the text coded at a topic and to pursue enquiry by rethinking and recoding as new meanings are reflected upon. The process of coding was a subjective and qualitative one drawing out themes and concepts described by the participants. We analysed the data in depth, revisited themes and issues, and looked for new emerging themes or patterns, including relationships and differences between themes.

We also applied exchange structure analysis developed by Kneser et al. (2001) as an adaptation of Sinclair and Coulthard's work (1992). This involved analysing whether a message was initiating a new thread of conversation or whether it offered a response to an ongoing thread or re-initiated through a request for clarification, refinement, challenge or justification. In continuing to look for indicators of deeper engagement as described above, we decided to code all the postings according to whether the post was best described as a monologue, a response to a previous posting, or a re-initiating turn thereby enabling us to focus on the distribution of different types of discourse. We chose each complete message as the individual unit of analysis as this enabled objective identification of units and clarified the number of observed units for analysis purposes. This is also in keeping with the 'unit 'as defined by the author of the message (Schellens, 2006). The issue of determining the impact that the type of discussion topic or question was measured in two ways: firstly according to the quantity of postings generated for each question across all groups; and secondly according to the distribution of the type of postings across the three groups. We collated all postings from tutors and analysed those postings in detail according to the themes of welcoming and affirming, instructing and modelling behaviour, intervening when necessary, challenging and giving feedback. Names of students and place names have been changed to preserve anonymity.

Results

The nature of the question

Looking at the overall data in terms of numbers of postings, they ranged between 490 and 1,266 in total across the 13 groups. There was a drop in quantity of postings over time in all groups with a greater drop between Module 1 and 2 than between Modules 2 and 3. The lowest number of postings in any one single discussion was 12 (with the exception of TimeToTalk 7 where there was a low number of postings across all groups due to the website servers being down). This indicated that despite there being a drop in postings over time, there were still sustainable numbers of postings for dialogue to take place in all discussions, with some discussions taking on the character of lively debate.

The number of postings and the nature of the discussions indicated a committed student group where most students participated if not all the time, then at least most of the time. Analysis of the discussions also showed that students largely adhered to the topic and focused on answering the question set. A count of the number of topic units corresponding with the question topic amounted to 92% overall.

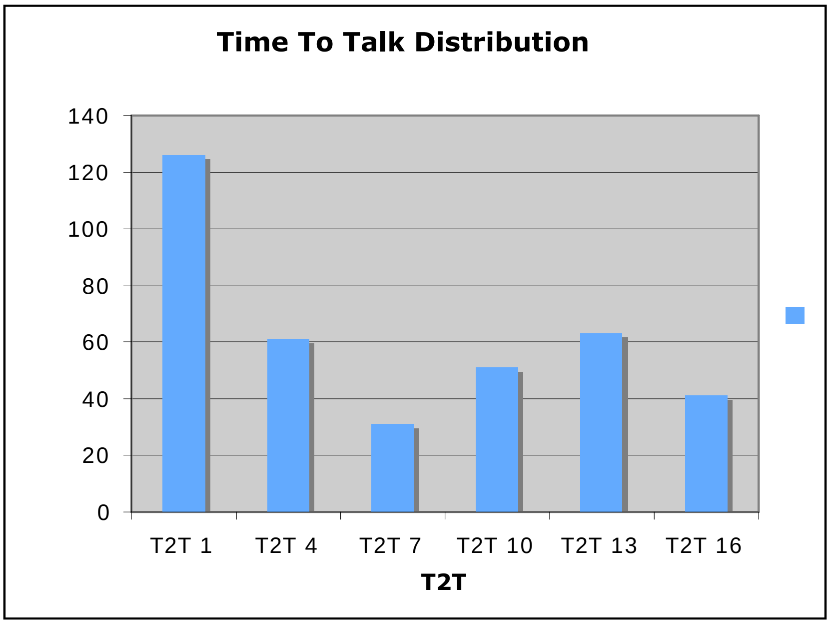

Figure 1. Quantities of postings across the three tutor groups:

In terms of the number of posts and the level of engagement with particular discussion topics it emerged that irrespective of whether the group was overall low, medium or high in number of posts, some discussion questions attract fewer posts across all groups (see figure 1). The wording of some of the discussion questions or tasks can be found in figure 2. In terms of quantities of postings, we see that the first discussion attracts significantly higher number of posts than the other discussions. TimeToTalk 4 and 13 had the second highest numbers of postings. The questions that attracted the fewest postings (with the exception of TimeToTalk7) were TimeToTalk 10 and 16.

We realise that purely measuring the number of posts would give us limited insight into discussions so this was complemented by examining distribution patterns of postings according to whether they were monologues, responses or re-initiates (see figure 3). The overall discussions were characterised by a substantial number messages being either monologues or responses (see figure 4). In fact, in all three groups those two different types of messages accounted for between 67 and 98% of the messages in each discussion. The first discussion had a higher number of responses and re initiating moves across all groups. TimeToTalk 10 had a lower number of 'monologues' and higher number of 'responses' in all three groups, indicating that students were responding to one another but the discussion was lacking in re-initiating moves in those discussions. TimeToTalk 16 showed similar patterns although this discussion was characterised by proportionally higher levels of monologues. TimeToTalk 4 was particularly characterised by a high number of monologues, particularly in two of the groups. This discussion read more like a series of individual reflective contributions than a discussion but could be important to students who appreciated the opportunity to share these reflections and felt they learnt from them. This discussion asked students to observe someone for 5 minutes and then to write down their observations. TimeToTalk 13 had more even balance, with some reinitiating moves in two of the groups.

Time to Talk Questions
TimeToTalk 1.Comment on whether you believe diagnosis is important or not. Think about an individual whom you care for or work with. Would it affect them whether they had a diagnosis or not?
TimeToTalk 4: Observe someone (it does not have to be someone with an ASD) for 5 minutes. Write down all the different ways they communicated in the time you observed them. Comment on whether they used language to communicate throughout. Did they communicate in other ways too? For example by using body language, facial expressions and other non-verbal communication?
TimeToTalk 10: Peeters and Jordan (1999) finish their article with the following words: "Amor NON vincit omnia. Autism is different". (Love does NOT conquer all). In your own words, comment on what you understand by this statement in the context of the article and whether you agree with it. Do you agree with the notion that carers and practitioners in the field of ASDs need to have characteristics that make them 'qualitatively different'?

Figure 2. The TimeToTalk Questions

Monologue
Group C, TimeToTalk 1, Linda: I work in a large special school, which has several classes for pupils who are diagnosed with an ASD. Without a diagnosis pupils cannot access this specialist provision and are placed in other provisions. We now have strict policy guidelines on staffing ratio and the staff work closely as team to maintain the ethos based around TEACCH, PECS and Intensive Interaction. We also have weekly Speech and Language Therapist (which other pupils in school access but in a more ad hoc manner than ours) Therefore the provision and resources for students with autism is in my own experience better than without a diagnosis.

Response
Group A, TimeToTalk 4. Elaine: I agree with Pat about the language and communication developing separately for those individuals with ASD. My son has good language but still needs help with the communication side. I write things down for him or use pictures with words and also he will write down stuff especially if he is anxious. I feel this helps him to understand more of what is happening at that moment.

Re-initiate
Group A, TimeToTalk 4, Maria: Where you mention looking through a window and still being able to judge the tone of the conversation reminds me of the clip on video of Karen Guldberg speaking in Norwegian. When I first listened and watched I could tell it was instructions but could only guess at one word "book". I knew she was giving instructions from the tone of voice and the spacing between sentences, but could not work out what the instructions were for. On the second clip where she used hand and body gestures I could see that it was some kind of bedtime routine and worked out that you needed to brush your teeth, read a book, have a drink, and go to bed. It wasn't until she used the symbols that I realised it was bath, brush teeth, have a story, have a bottle, and go to sleep, and that this related to a baby. It has really made me think about how my R must find it so confusing at times when just language is used and especially when she might be anxious due to sensory difficulties. I believe it will be most beneficial to use symbols at certain times as an aid to helping her understand. After all we are speaking a kind of foreign language to her, and even if she can pick out a few words the meaning may still be lost to her. What do other people think?

Figure 3. Examples of different types of discourse

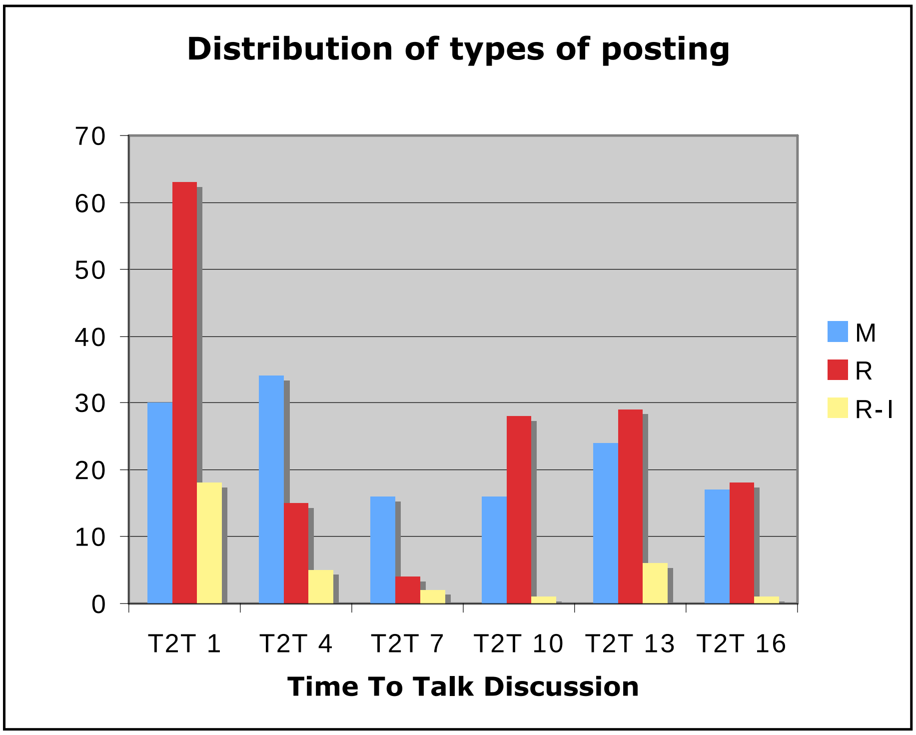

Figure 4. Different types of postings across all three groups: Monologue (M), Response (R) and Re-Initiate (R-I)

There was limited amount of disagreement between students. Out of the total 18 discussions, there were only two discussions that lead to any disagreement or slightly differing perspectives being put forward. Even then, messages indicating disagreements were limited to between 4 and 8% of the overall messages. The two questions in which disagreement was expressed, were posed in such a way that they sought students' opinions on matters that they were likely to have an opinion on and which they could comment on in relation to their experience. The first questioned whether they believed diagnosis was important for the person with an ASD and the second discussion question asked students to comment on an article they had read and to contribute on whether they thought carers and practitioners in the field of ASDs need to have characteristics that make them 'qualitatively different'.

We found that the questions that gave students opportunity to share personal experience often created longer more monologue-like contributions punctuated with briefer (for the greater part) affirming responses. (see figures 2 and 3). Other questions showed a more even match (in length of post) between initial and responding messages and chains of interaction in which themes and responses were in turn responded to. These discussions had the character of lively and challenging debate. TimeToTalk 1 and 13 were particularly characterised by these types of postings. The questions posed for these discussions tended to give students an opportunity to reflect on practice more generally and less personally, giving them the opportunity to voice opinions. Questions that produced the lowest frequency of response were those that students found difficult perhaps because they felt ill prepared through lack of prior reading or had little experience in that area such as the question in Time to Talk 16 (see figure 3) Questions that asked students about their understanding of technical terms or required a detailed knowledge of reports or codes of practice showed less engagement.

In terms of numbers of words per post across the three different groups, these ranged between from 191 to 302 in Group A, from 178 to 231 in Group B and from 115 to 213 in Group C. We see from this that the lowest posting group tended to have longer postings whilst the highest posting group tended to have shorter length postings.

The role of the tutor

In the programme described here we wanted, as far as possible, for the students to 'forget' the eyes of the tutor and have opportunity to develop discussion skills necessary to reflective practice. We wanted these to happen naturally between students without inhibition generated by active tutor participation hence the non- interventionist approach. This approach was predicated on the need for highly structured tasks so that students would know what was expected of them and on topics that would encourage participation because students were sufficiently prepared for them and because they related to their practice and level of expertise. Tutors were expected to monitor discussion to provide a check that students were interpreting the task correctly, engaging with it and contributing productively. Moreover, at the close of discussion, the tutor summary was expected to provide formative feedback – an opportunity for the tutor to review and comment on student contributions in constructive ways. The summary gives the students an overview of the discussion, enabling them to step back from their own intervention in it and reflect on what has emerged from it both in terms of content of the discussion and their own learning/skill development.

The first aspect of the tutor role was a welcoming and affirming one. Tutors were encouraged, in the first module, to support and reassure students by addressing them by name and giving them positive feedback thereby helping them to feel that their contribution was valued. There are many examples of encouragement and positive feedback during the discussions (see figure 5). In subsequent dialogues tutors do not generally intervene in the discussion after the initial posting of the discussion topic until summarising at the end. After the first three discussions, we found very few examples of the tutor intervening in this way. Tutors still showed evidence of affirming students but mainly through the summaries (see figure 6).

Edward	As a first 'run at it' this was a lively and committed discussion.
Claire	Welcome to a new term's T2T. Hi Katie, good to see your message! Welcome. Hope to see you soon at our first f2f. Cheers Claire
Edward	Thank you for your participation in the exchange of ideas, any courteous challenges made and the reflection on your own and others view points.

Figure 5. Giving formative feedback or reassure/empathise with students

Tutor Summary: Fiona	This discussion was emotional and generated very interesting ideas. I could feel the frustration you experienced while writing about lack of understanding and support in mainstream schools that sometimes made the school life of children with ASD miserable and confusing.

Figure 6. Extract showing affirmation of students through tutor summary

We also see the tutors taking on the roles of instructing and modelling behaviour. The tutors' main influence was through summary writing and they did not therefore directly influence the development or flow of the discussion. Tutors varied in how much they used the summary to comment on the ways in which the discussion itself developed. In early discussions tutors were more likely to name particular individuals as having raised themes, thus giving personal affirming feedback (see figure 8). In later discussions, tutors focused more on synthesis of content themes and on the discussion as a whole rather than on establishing relationships with students through individual validation. One tutor commented on how this was deliberate - consciously shifting the role of the summary away from giving reassurance and individual feedback toward modelling what they regard as a good summary (see figure 7).

Edward	The way that Time to Talk works is that each discussion has a set period, at the end of which one or other Tutor will summarise the arguments advanced and the points made. It is good practice to mention how contributors came into the discussion; but, of course, it is not the object of the exercise to repeat in full exactly what anyone said. The summaries in this first term will largely seek to be factual and the Tutor will refrain from comment. At the end of each, however, there may be an idea from your Tutors that may spark a thought or two; to be stored in the back of the mind and to be brought out again as the Course progresses. Times to Talk are, in that sense, cumulative and build on one another.

Figure 7. Explaining the role of tutor as T2Ts progress

A fourth aspect of the tutor role was intervening in discussions when needed. This did not happen often but tutors did intervene in certain instances. One was when the tutor had to answer a direct question from a student. Another was when the tutor felt the need to remind students that posting messages and participating in dialogue was a requirement of the course. The third instance was when the tutor needed to curb students' enthusiasm when they started a subject matter too early. One tutor also felt the need to remind students about how to compose messages in a way that would aid subject flow.

Tutors also showed evidence of challenging and giving feedback. This was often done in a subtle and supportive way, making students feel that their contributions had been noted and were valued (see figure 8).

Edward	Yesterday I was attending a one-day Conference on autism; and therefore my apologies for the day's delay in posting this summary. Nevertheless, it was interesting, in coming to your TimeToTalk threads, to note the convergence of ideas between those and what was set out. in the Conference. One theme, strongly put across, coincided with Nina's that there is a common need for child-sensitive education, individually focused (Emma, Ursula, Diane) that goes way beyond ASD. Broadly speaking, if a method has advantages for a child with ASD, then it can illuminate aspects of education for all children. To be able to bring together these element 'effectively', there is a need to acquire a knowledge base about the said underlying philosophy and methodological "strategy' of many (if not, indeed, all) of the offered systems (Claire). It is now time to pass on to the next topic area, which I hope will be as equally stimulating. After this evening this topic area will close.

Figure 8. Tutor modelling own expertise or skill as a practitioner, teacher, or critical discussant

Discussion and findings

Our Case Study research has taken note of McConnells (1994) call to conduct more research in real settings where participants use the medium for important, meaningful and purposeful reasons. From analysis of a real-life learning situation our challenge has been to find out what tutors do and why (Oliver, 2006) and to look at the impact of the management and selection of tasks, discussion groups and topics together with tutor interventions on subsequent discussion outcomes.

Decisions about the type of questions to ask students and how to encourage cognitive, reflective or interactive skills through the use of questioning, need to be made in the context of specific learning environments and should be set with the particular student group in mind. The pedagogical advantages of online collaborative learning are well known and we concur with Macdonald's research, which highlights that integration of collaborative learning and hence also dialogue within the course will radically influence its uptake (Macdonald, 2003). In this course, discussion questions are carefully integrated with online presentations, and reading material. This is likely to affect adherence to topic as discussion takes place with a structured environment.

An important role of the teacher is to set tasks and questions that will generate discussion in line with the aims of the course. In this course, the questions were aligned with the learning outcomes of the programme, as the focus was on developing reflective, team- working and problem-solving skills in the students whose background necessitates an empathetic and reflective stance. Course tutors recognised that the students on this programme usually arrived with a strong need to talk about their experiences and that the opportunity to talk about experiences was likely to lead to the development of confidence and motivation. The pedagogical considerations of the course had applied the concept of 'scaffolding' (Bruner, 1983) to the nature of the questions set. The aim was to 'scaffold' the students through their assessed work (and this was mirrored in Time to Talk questions) from being given opportunities to comment on their experience, through to being able to argue something from one point of view to finally commenting in a more balanced way looking at a variety of points of view. We see through the data that the students are comfortable with the first two stages but are still reticent to reach that third stage of criticality. This is an issue that the course designers can address in that there may need to be more careful thought attached to moving students from the notion of commenting on experience to arguing something from a more balanced point of view, in order to express criticality and disagreement.

Our findings highlight the need for course tutors generally to think carefully about the pedagogical considerations of their courses and to consider the types of questions that need to be posed in terms of meeting the relevant learning outcomes. Our research highlights the importance of creating a safe environment for students. One way to do this can be to focus on the types of questions asked at different stages of a course. It may be valid for other course designers, in line with Salmon's five stage model (Salmon, 2000), to aim to ask questions which encourage engagements on a social, personal and reflective level at early stages but then gradually introduce more cognitive demand as students progress through the course. This is particularly true for undergraduate students who have little experience of studying in Higher Education and might need to develop confidence and practice online interaction before being expected to engage in more cognitively demanding tasks.

Previous research has found that complex interactions tended to happen when the question was specific or it was a concept covered in a course reader and that discussions would fail if questions were too broad and open (Fung, 2004). We found that the issue was not so much whether the question was broad or focused but was related to the way in which students were asked to comment on experience. If questions were directly related to personal experience, then they tended to result in longer more monologue type contributions that tended to close discussion down. When reflecting on practice more generally and less personally, then we found shorter contributions, which had more interactive nature and the character of lively debate. This was particularly true if the question encouraged students to reflect on a particular concrete case or personal experience but then asked them to express an opinion on a specific issue for example if diagnosis was helpful or if a particular form of teaching was beneficial. Questions that were more open in asking students simply to raise issues in general that emerged for them may be less successful in generating debate.

Our interaction analysis found differentiation in the types of exchanges generated by different questions and this may be of interest to course designers in general. If we look at the relationship between structure and form, it has been argued (Kneser et al., 2002; Pilkington, 2003) that reinitiating forms tended to open up discussion for further elaboration and refinement whilst responses and their complements tend to be informative or provide feedback but close discussion down. Thus, the clarification and challenge occupying the re-initiating position within discussion can be an indicator of deeper engagement with each other's contributions. Less interactive discussions may be characterised by an initiating question (often posed by the tutor) with a series of informative replies by different respondents or the conversationally ill-formed initiate-initiate sequence where one person provides an informative comment followed by another unrelated informative comment (typical monologue).

This seems to be the case in this research and we feel it is important to look at context to understand why this may be so. The course is a continuous professional development course with a focus upon reflection and practice. This particular context, coupled with the needs of the student group, means that the course is focused upon developing reflective abilities and confidence about practice. It is in this context that we found that the online exchanges described here have tended more towards descriptions of personal experience than well-supported, subject-related reasoning (Angeli et al., 2003). This leads us to the conclusion that whilst it can be difficult to know how to evaluate the learning experience within Virtual Learning Environments, evaluating the extent to which interaction occurs or the syntax of interaction without also considering its semantic content, is not enough, particularly given that reflection is an important skill and process to develop (Gibson, 2006). We therefore need to develop other methods of analysis that allow us to measure not only the quality of interaction but the extent to which reflective abilities are developing.

The tutor clearly has an important role to play in enabling these reflective skills to develop. In this course, the role of the tutor has been shown in some ways to be similar to other e-moderator environments in that the tutor's role is to open the discussion, to help motivate learners, to encourage students to talk and share, and to highlight when it is time to move to the next discussion. Yet, the moderation role is also very different. This research shows that it is possible to enable discussion whilst giving the tutor a less interventionist role than we would normally expect the tutor to take on. Traditionally, the tutor's role is based on the premise that the tutor should take a leadership, which involves taking control over many aspects of the discussion. We would argue that it is possible for tutors to modify this role by taking a less interventionist role than is often expected. The supportive structure, coupled with the notion of the tutor as an 'enabling participant', can then lead to a focus on the student group itself and participants' belonging to that and it moves students away from the perspective of tutor as 'expert'. This seems particularly important in a course that is about enabling people to become more reflective and is also about enabling students to rely on their own judgement in relation to practice.

Concluding comments

Our research found that the type of question posed to students has an impact on subsequent discussion patterns and leads to particular types of contributions from students. We found that some questions were better at enabling dialogue and reciprocity. These were questions that asked students to reflect on a specific personal experience and to express an opinion about an area of practice. Questions that gave students opportunity to comment on their own personal experience resulted in more monologue style exchanges. The research highlights that selection of questions for online discussions are important and need to be chosen in line with the learning outcomes and aims of a specific course.

We found that careful structure on behalf of the tutor in advance of a discussion can contribute to the development of discussion skills amongst students and that tutors can therefore be encouraged to take a less interventionist role has sometimes anticipated. We believe the key to success of this online course, is the integration of discussion tasks with good quality resources and regional tutors who give students plenty of time to talk amongst themselves, give supportive and reassuring comments, yet do not interrupt too often. Students talk in lots of different ways and for different reasons but we are learning that many of these are all important to a sense of community and, in the end, to helping each other learn.

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The Role of Blogs In Studying The Discourse And Social Practices of Mathematics Teachers

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ABSTRACT

This paper introduces a rationale for change in roles and practices of the participants in mathematics education MA courses and their instructor, based on the integration and use of a web log, both as a medium for asynchronous communication, and as a mechanism for provoking professional reflection, through changes in the discursive style and the social practices of participants. It reports research carried out with 48 mathematics teachers, as students of two six-month academic (MA) courses. A framework for research and practice in on line learning (Garrison & Anderson, 2003) is related to theoretical constructs from the fields of mathematics education and online learning and is used as a first analytical filter. In terms of identifying kinds of discourse, the analytical categories used have aided in clarifying specific patterns. The first seems to be that of the development of different writing genres and the informal discursive style embedded in teachers' narratives. The second is the effort of participants to engage in communicatively demanding situations, adopting different roles and behaviours. These roles and behaviours are summarised in three profiles: the "blog enthusiast", the "blog frequent visitor" and the "blog sceptic".

Keywords

Web logs, Professional development, Discourse, Mathematics teachers

Introduction

Rebecca Blood (2003) defines web logs (abbreviation: blogs) as "personal or organizational web pages organized by dated entries, with newer items posted to the top of the site, usually consisting of links, media, commentaries, personal thoughts, essays, papers and ongoing discussions".

Blogs can be published by a single or multiple authors, with varying editing permissions, and, according to Bartlett-Bragg (2003), exhibit five representative features: personal editorship, a hyperlinked posting structure, frequent updates, free public access to the content via the Internet and archived postings. O' Donnell (2005) refers to the blog's "idiosyncratic rhetoric", which "transforms the textual experience into an epistemologically challenging game", while Mortensen and Walker (2002) argue that the blog reverses the "tyranny of logical argumentation" by imposing the organization of posts in chronological order.

Since 2000, when these tools became widely available, a surprisingly wide variety of blog uses can be observed in the higher education and research arenas. In the field of higher education in particular, where online asynchronous communication has taken place, either through email or discussion boards, blogs have been used in a number of different roles, which have both extended and in some instances replaced existing online communication tools (Farmer 2004). This has triggered recent research indicating the usefulness of blogs as communication and/or cognitive tools for specific disciplines, such as language learning (Ward, 2004), journalism and communication studies (O' Donnell 2005), academic research (Mortensen & Walker, 2002), law, higher education in general (Williams and Jacobs, 2004), and teachers' professional development (Carraher, 2003). There seems, however to be a gap in the related literature with regards to the potential and possible role/s of blogs in the professional development of mathematics teachers and the possible change they may bring about in roles and practices currently employed, both by students and lecturers.

Oliver et al (2005), in their report of empirical studies of the impact of ICT on roles and practices in higher education, underline the significant relationship between subject and discipline area and the specific use of technology it evokes or encourages. These authors, having carried out research on a national scale in the UK higher education system broadly recognize two main types of technology use: a) Physics, Engineering and Mathematics and b) Social Sciences (such as Politics, Languages and applied Social Sciences). For the first category, the use of digital resources was closely related to the use of specialist software, (use of images, including moving and 3-D images and simulations). For the second category, the interest focused on the use of particular types of web based materials. What the authors consider as noticeable is that "*maths and science based subjects did not direct students towards journal use of any kind until the final stages of an undergraduate program, whereas social science and arts students were more likely to make use of journals and e-journals throughout their degree*" (p.36).

On the issue of the added pedagogical value online learning, Kynigos, Dimaraki and Trouki (in press-a) claim that if it is intended to be meaningful, research cannot be restricted to communicational tools per se, without a rationale supporting this communication, addressing the need of "*weaving together tools and learning process*". On the issue of educational uses of blogs in particular, O' Donnell (2005:1) argues that they "*should not be seen merely as a technological tool for teaching and learning but as a situated practice that must be brought into appropriate alignment with particular pedagogical and disciplinary practices*".

Framework Of The Study

In line with the above arguments, this study introduces a rationale for the introduction of blogs in two six-month, post graduate academic courses for teachers of mathematics. Its basis is the premise that learners' personal worlds (reflective and meaning focused), as well as the shared world (collaborative and knowledge focused), if associated with a purposeful and structured educational environment, could provide a worthwhile learning experience (Garrison et al., 2000). This premise has been further elaborated by Garrison and Anderson (2003), as a framework for research and practice in the field of on line learning, identifying three key elements as decisive of any successful on line educational environment: social presence, cognitive presence and teaching presence, defined as follows:

- social presence

"When participants in an online course help establish a community of learning by projecting their personal characteristics into the discussion — they present themselves as "real people." The authors identify at least three forms of social presence: affective (expression of emotion, feelings and mood), interactive (reading, attending, understanding, thinking about other's responses) and cohesive (responses that build and sustain a sense of 'belongingness', group commitment, or common goals and objectives).

- cognitive presence

"The extent to which the professor and the students are able to construct and confirm meaning through sustained discourse (discussion) in a community of inquiry". It is demonstrated by introducing factual, conceptual, and theoretical knowledge into the discussion, the value of such responses depending upon the source, clarity, accuracy and comprehensiveness of the knowledge.

- teaching presence

"Teaching presence is the facilitation and direction of cognitive and social process for the realization of personally meaningful and educationally worthwhile learning outcomes". There are two ways that the professor and the students can add teaching presence to a discussion: 1) by facilitating the discussion and 2) by direct instruction.

Cognitive presence relates to the learners' personal worlds, social presence focuses on learners' shared world, whilst teaching presence insures a structured, purposeful learning environment for the other two elements to coexist. In the following sections, social and teaching presence are related to the potential of the blog for changing existing social roles and practices. Cognitive presence is related to changes in participants' discursive style.

Use Of Blogs For Change In Social Roles

In educational practice integrating digital media, there is an increasing interest in the study of changing social practices and roles (Oliver et al., 2005; Price et. al., 2005). Especially in higher education, technologies allowing asynchronous communication to occur among students and tutor expand the existing communicational and interaction patterns. Furthermore, such technologies also seem to impact on the traditional role of the university instructor. Research in this area (Lairson, 1999, in Price et al, 2005) indicates that, by adopting "on line" extra materials and integrating them to their lessons, academics re-conceptualise their roles and, in certain cases, adopt new ones.

Moreover, the interest in social practices is also a prevalent one in the research community of mathematics education, manifesting itself as a shift to a "*social approach to research in mathematics education*" (Hoyles, 2001, p.273). Having generally accepted that the social context affects the nature of learning activities and outcomes (Resnick, 1991), researchers now study the social and discursive practices of mathematicians. Solomon (1998) goes as far as to recognise the social practices of mathematics as "constitutive of its meaning".

With regards to blogs' social dynamics, recent research has shown that they engender a new form of social interaction on the web (Marlow, 2004). Hiler (2003, in Williams & Jacobs, 2004) has characterised them as "the killer app", in terms of their capacity to engage people in collaborative activity, reflection, knowledge sharing and debate. They "*provide a genuine audience, that is authentically communicative, process driven, peer reviewed, provides a dis-inhibiting context and offers a completely new form with un-chartered creative potential*" (Ward, 2004 p.3). Mortensen and Walker (2002, p.253), based on Heim's approach on the ways in which word processing affects thought process, claim that "*the way one expresses self in a blog reveals something about the way he or she thinks, which would not be explicit in another medium*".

Furthermore, Boyd (2003) introduces the term "social software", juxtaposing it to project-oriented collaboration tools and Learning Management Systems (LMS), and characterising blogs as a good example of this dynamic. He argues that social software is based on supporting the desire of individuals to affiliate, their desire to be pulled into groups to achieve their personal goals, in contrast to the groupware approach, where people are placed into groups defined organizationally or functionally. Having analysed blogs' communicational attributes, the same author claims that they allow for the creation of new social groupings and the arousal of new social conventions. Bartlett-Bragg (2003) also pinpoints the differences between blogs and centralised, organisational systems (LMS), concluding that:

> "Through the use of blogs, it is suggested that teachers and learners are becoming empowered, motivated, reflective and connected practitioners in new knowledge environments. The balance between individualised and centralised technologies is restored".

This research examines the particular changes in roles and practices of the students and instructor of the particular research setting, under the lens of the constructs of social presence and teaching presence of Garrison and Anderson' s framework. In a traditional university lecture, all three forms of social presence (affective, interactive and cohesive) may be present. However, time constraints and the disruption of flow of content delivery don't allow for a great degree of manifestation of interactions of this kind. In addition, the introduction of the blog raised the issue of complicating the role of the instructor. The double metaphor of "facilitator of discussion and direct instructor" included in teaching presence existed before the tool integration, but further expanded through the use of the new medium. A central issue, thus, for this research was if the use of the blog allowed for changes in the social orchestration of the courses, in terms of affecting the existing patterns of communication among students-peers and the role of their lecturer.

A View On Blogs As Personal And Professional Instruments

The instrumental approach stems from the field of cognitive ergonomics, embracing an ecological view of human activity with artefacts, based on Rabardel' s elaboration of the key Vygotskian concepts of mediation and activity theory (Guin & Trouche, 2005). It presupposes a clear distinction between a technological artifact and the –one or multiple- instruments that people are inclined to build out of this artifact. According to Lagrange et al. (2001, p.6) "*While the artifact refers to the objective tool, the instrument refers to a mental construction of the tool by the user*".

Thus, an instrument consists of "*the artefact and the modalities of its use, as elaborated by a particular user*" (Mariotti, 2002, p.702). Artifacts per se, though bearing certain affordances, do not incorporate instrumental value, but rather become instruments through a generative and complex process triggered by the user, which has been characterized as "instrumental genesis" (Verillon & Rabardel, 1995). This process results in the construction of "personal schemes of use" (Artigue, 2001, p.4), the latter functioning as organisers of the activity of the user and pointer of how the artefact has actually been used in a given situation. As different and coordinated schemes of use are successively elaborated, the relationship between user and artefact evolves (Olivero, 2002, p.50).

Rabardel proposes a conceptualisation of instruments as "private and social entities" (Guin & Trouche, 2005). Schemes are also social because they have characteristics that are both shared and widespread in communities. Therefore, Rabardel considers designing instruments as an activity distributed by designers and users, evoking the idea of *conception in use* (ibid.).

In the light of the suggestion that the instrumental perspective could be considered as a design factor for teachers' professional development (Kynigos, in press-b; Guin & Trouche, 2005), the question of whether blogs would be appropriated by teachers after the end of their courses arose. Hastings (2003) points out the duplicitous nature of the blog, which can be, "*a frequently posted list of interesting web sites, or a personal diary of events and thoughts, or a combination of the two (among many things)* (Hastings, 2003:1). Mortensen & Walker (2002) see blogs as "*existing on the border between what's private and what's public*" and consider a blog as "good", if it contains a tension between the two spheres. Blogs constructed by teachers after completing their obligations as MA students and returning to their classrooms are considered as personal and social schemes, because of the characteristic of blogs to promote an interplay between the social and the individual "voice". Having experienced the creation of a group, classroom blog, shifting to a personal use of the tool would provide interesting insights on the issue of the degree to which the particular audience conceptualised the use of a specific "artefact", as a personal and professional "instrument".

However, adopting blog use for personal or professional purposes isn't necessarily an effect of using them throughout a course, especially for mathematicians, who are not accustomed to this mode of communication. Bartlett Bragg (2003) introduces a five step model of blog use by students in higher education, which begins by just adopting the use of technology (stage 1), to fully appropriating it and creating "knowledge artefacts" (stage 5). O' Donnell (2005) identifies specific "hurdles", not so much as discrete phases but as parallel tracks, to move from willing volunteer to competent blogger. The above considerations were taken in mind whilst designing a non-obligatory blog publishing seminar during the course, which would unburden any teacher interested in further using the tool from potential technical problems.

Potential Of Blogs For Teacher Reflection

In mathematics education, the shift towards socio-cultural and discursive approaches (Lerman, 2001) has increased the interest on communicative acts and performances of scientists and mathematicians, and in particular on their rhetorical practices (Ernest, 1999), with a parallel concern with writing genres (Marks & Mousley, 1990). With regards to the prevailing discourse in mathematics, van Oers (2001, p.278) argues that it is governed by rules that are "*systematic, consistent, symbolic and abstract*". As MA students and school teachers, mathematicians have to "*obey to specific and rigid stylistic criteria that mathematical knowledge representations or texts are required to satisfy within the research mathematics community* (Ernest, 1999, p.76). These disciplinary restrictions affect the way mathematicians write for each other. Pimm (1989, p.42) refers to this way as a "problem": "*Reading mathematical writing is extremely difficult […] Elegance in measured in part by brevity and in part by simplicity. Accessibility plays no part*".

Solomon and O' Neil (1998) claim that any deviation from the standard discourse used in scientific subjects would appear as a "challenge to dominant literacies". As Ernest (1999) warns, such an approach would involve a major shift in genre and rhetorical demand, away from an impersonal, standard code, towards a more personal account of mathematical investigation. This would allow for other, not very common genres to develop. According to Solomon and O' Neil (1998), mathematics utilizes a number of genres: descriptive, procedural, explanatory, expository and narrative. However, the authors point out that the prevailing genre in mathematics classrooms is the recount genre, as a mere recollection of events.

With regards to the rhetoric induced by blog use, O' Donnell (2005, p.3) characterizes it as "idiosyncratic", and states that it "*transforms the textual experience into an epistemologically challenging game*". Mortensen and Walker (2002) specifically refer to the organization of posts in chronological order and argue that this feature reverses the "tyranny of logical argumentation" (a term introduced by Roland Barthes).

The above features were considered as crucial to designing writing tasks for the teachers, which would "perturb" their roles and practices, by encouraging deviations from their usual discursive style. In the language of rhetoric and communication, the specific writing tasks were aimed to be "ill-structured problems", the latter defined by Flower et al. (1989) as a rhetorical situation, in which the subject has no clear instructions on how to proceed to a solution. In contrast to "well structured problems" (e.g. games) where there exist written, coherent rules, there are no ready made solutions for writing problems. Adopting a view that differentiates authoring from mere publishing (Streitz, 1994), writing is seen as a complex problem-solving and design activity. The whole composition venture aimed at operating as a mechanism for reflection and self-evaluation, through a change in the mode and medium of communication previously employed.

In addition to the wording of the writing tasks, deliberately non-directive and open-ended, the role of technology was also left implicit. A basic premise of the blog use rationale was that teachers don't learn effectively if they adopt the "manual style" of learning a piece of technology, making the technology itself the object of study and rote learning the functionalities of the tool. It is much more effective for teachers to learn in a contextualised, theme-based style, where technical know-how comes gradually as the need arises form the problem situation at hand (Kynigos, 2003). Whenever teachers were found to participate in a design including facing a "problematic situation", where the role of technology was not predefined, the problem did not "solve itself" by pushing a button or proof reading a manual, but through discussion and experimentation with the technological tool (Kanstrup, 2003). During the process of involvement with the problem, several methods, models and theories are tested before a proposed solution is reached. This form of problem solving could be better conceptualised through the metaphor of "bricolage" (Lévi-Strauss, 1969), used to depict this rational for the craftsman (Harper, 1987) and technician (Orr, 1996) professions. Kanstrup (2003) proposes the exploitation of this idea within the teaching profession, claiming that this view is not far from that Schön's "reflective practitioner". Teachers' work with technology is, according to this view, considered as a "reflective dialogue with materials" or, "bricolage". "

Research Questions

Based on the ideas discussed in the previous sections, the research questions formed were the following:

- *What was the nature of the discourse teachers developed on the blog? Does it differ from commonly accepted norms in mathematics research?*

By the term "discourse", we refer to the ways teachers write both about their subject, and its pedagogy, while addressing to a "real" audience, thus adopting an approach perceiving the two kinds of growth (mathematical and pedagogical content knowledge) as an integral part of teacher growth (Shulman, 1986; Kynigos, in press).

- *Which changes in social roles and interaction does blog use evoke, both for the students and for the instructor?*

Change in social roles refers to schemes emerging during blog use by the students themselves, and not the actual groupings assigned by the instructor –the latter were conventional, so as to organise and structure the activity.

- *Has blog use evoked any change in the participants' future professional practices?*

This question refers to the degree of tool appropriation, as a "scheme of use" created by the particular audience.

Methodology

An influential idea informing the research methodology is that of "design" in learning (Cobb et al, 2003; The Design Based Research Collective, 2003; Kynigos, 2002b), an emergent paradigm for the study of teaching and learning processes in authentic and contextualized environments, integrating the use of technology (Collins, 2002). According to this framework, good design should lead to a system which is stable enough, to serve initial design and flexible enough, to correct and expand it (Kynigos, 2002a). A crosscutting feature of this approach is its highly interventionist nature, as it aims at deliberately engineering specific learning situations –differing from traditional ones- in order to study them and has been characterised as "a test bed for innovation" (Cobb et al, 2003, p.10). These educational interventions are viewed holistically, as "enacted through the interactions between materials, teachers and learners" (The Design Based Research Collective, 2003, p.5). They often entail the use of new resources, such as software applications, and commit in promoting understanding the relationships among theory, designed artefacts and practice (ibid.).

This research is considered to be bearing the above characteristics. However, having in mind that design research is rather an informing rationale than a specific research technique and thus relies on techniques from other paradigms, and since the data we needed to collect were of a qualitative nature, we have employed the case study approach. The latter is recommended by Creswell (2002) if the problem to be studied "relates to developing an in-depth understanding of a "case" or "bounded system" (p. 496) and if the purpose is to understand "an event, activity, process, or one or more individuals" (p. 496). Our purpose was to gain an insight into a particular learning situation.

Data Collection Instruments, Participants And Procedure

The research audience comprised of a total of 48 individuals, participating in two courses, the one focusing on the teaching and learning of mathematics, and the second on teaching and learning of mathematics with technology. The courses' duration was one academic semester. The rationale underlying the course structure is based on the premise that teacher education is perceived as professional development activity addressing teachers' epistemologies, practices, pedagogies and subject-related knowledge (Kynigos, 2003). Students were introduced to the "class blog" at the beginning of the semester, and were assigned specific writing tasks addressing their epistemological and pedagogical beliefs as well as their subject related knowledge. What they were assigned to do was publish their answers to open-ended questions and problems on the blog, make their ideas explicit and "readable" by others, and also comment on the work of their peers. They were expected to use the blog as a "problem space", where they would represent the problem under consideration, and also their route towards a viable solution. They were also encouraged to share opinions and engage in discussion, posting on each other's entries on a regular basis, and there was frequent reference and browsing of the site by the instructor. During the course, they were offered a non-obligatory seminar for constructing blogs for their own classrooms.

The data collected were written transcripts from the participants' entries, observation notes, informal interview transcripts and a final evaluation questionnaire.

Analytical Framework

The Garrison and Anderson (2003) framework was used as a primary filter for data analysis. Cognitive presence was related to the research question on the changes in social interaction and the role of the instructor. Cognitive presence was related to the question on the kind of discourse developed by teachers. Data was first labelled according to this scheme, whilst the issue of blog appropriation as a personal or professional instrument was examined through the observation of the evolution of three individual cases, in which students took the initiative to design their own blogs.

This filtering led to shaping a first idea of the basic emerging social and discursive patterns. However, in the course of the analysis, new elements situated in the specific research setting appeared. Such an element is the social act we identified as frequently occurring, that of narration, which was not included in the initial Garrison and Anderson' s framework. Any narrative, however relative to a previous post, cannot be considered as a response to it, but rather as a personal account. Furthermore, we identified two kinds of narratives: single stories, narrated by individual teachers; and emerging collaborative constructs, shaped by multiple authors, in a the course of a specific time span of conversation. This led us to refer to Shulman's (1987) categorisation of teachers' narratives as: a) experiential, b) interpretive of a situation, c) reflective and d) transformative, each category being more important than the previous one in terms of professional development. For the purposes of this analysis, teachers' narratives were examined through this lens.

Findings

On social presence

All three forms of social presence seem to co exist in the participants' entries and comments, with interactive and cohesive forms as the most frequent.

Excerpt 1 is a representative example of interactive presence, formed around a given problem:

EXCERPT 1:

Post of student A. to a scenario of use of specialised software for Geometry, posted by student S.

> *"This is a very good idea, S. Now, knowing this relation (that of angle f to the central angle w of the polygon), we could help our students a little, to build this program (they must know, of course, what is an external angle):*
> *to polygon:n:a*
> *repeat:n [m :a d 360 / :n]*
> *end*
> *Using the variation tool they could augment the sides, that is, to make a shape with angles, then a one with 20, then one with 40, etc, and make the assumption that as n augments (keeping x at a fixed value), our shape tends to become a circle".*

Answer of student S

> *A., you seem to be inside my mind. I didn't mention this, because I consider it as a different teaching unit. As for the external angle, it is in fact the angle of the turtle turn, and that is something pupils can "discover" by themselves. Thanks a lot for your comment.*

This interaction indicates understanding and thinking about each other's responses in the given problem. Student A responds to student S's teaching idea by extending it, the latter expressing her agreement and resonance.

The student's response in excerpt 2 shows a continuity –in the form of reciprocity- in communication flow:

EXCERPT 2:

> *You are absolutely right, and this is a question I expected someone would ask.*

It can therefore be considered as a sample of cohesive presence, indicating a sense of group commitment, in the form of an expectation of a particular response.

Excerpt 3 is one of the very few samples of affective presence. The student comments on his colleague's teaching idea (on class inclusion, with a real-world problem on the issue of the weight of a lorry and its contents)

EXCERPT 3:

> *This is an interesting and realistic teaching idea, especially bearing in mind that, in the case of class inclusion, many young children start dividing, in order to solve such a problem. Have you thought of the possibility that the little boy would want to burn his father' s lorry?*

The student extends the cognitive issue of class inclusion by connecting it to a hypothetical event, employing his sense of humour, a basic element of cohesive presence.

On teaching presence

Both two forms of data, written and oral (from classroom observation), indicate a certain degree of teaching presence, both in terms of facilitating the discussion, and by direct instruction. An instance of the first case is shown in excerpt 4 below, presenting the instructor' s reaction to a students' entry on the role of the teacher:

EXCERPT 4:
Post by student N:

> *The role of the teacher is to offer the proper stimuli, which can aid the small explorers personally construct knowledge.*

Instructor's comment:

> *Hmm... Sounds good to me, but, who acts this way? Where is this prescribed? Does the school and education community agree with it a) on a theoretical and b) on a practical basis?*

This expression of teaching presence triggered a long discussion, which oriented students towards using more precise examples for supporting their theoretical views.

On cognitive presence

Cognitive presence is quite frequent in tasks related to the design and presentation of small teaching units, after working with specific software, as well as similar tasks not involving the use of technology.

Excerpt 5 is a response of a two-member group to a colleague who had posted a comment on their teaching idea:

EXCERPT 5:

> *M., no, we don't agree. The reason we posed the question in this form is because we wanted our problem to resemble the writing style of Margaret Donaldson, since, at the lesson, we had commented on the fourth chapter of her book "Children's Minds", which refers to class inclusion. If you look at the bottom of page 45, you'll see the following two questions [written in English]:*
>
> **Are there more red steps to go to the chair or more steps to go to the table?*
>
> **Are there more steps to go to the chair or more steps to go to the table?*
>
> *It comprises a reference to specified theoretical knowledge, with clarity and accuracy, declaring their source.*

On teachers' narratives

The majority of the teachers' narratives were experiential, such as the one in excerpt 6 below:

EXCERPT 6:

> *Triggered by the problem [instructor name] posed during the lesson, I recalled a problem which had perplexed me during the years of my early youth, its solution having demanded many hours of my precious sleeping time. At a later time, as I was skimming through the literature, I realized that this particular problem had been posed (as an exercise of competence) by the great Fermat to Toricelli, who solved it immediately, followed afterwards by many others, in various ways (this fact pointing once more, to my triviality).*

Narratives like this are frequent, as individual stories not intending at evoking any specific kind of interaction.

Another form of narrative are stories embedded in the course of a debate, such as excerpt 7, being the 6th comment in a row of 9, responding to a question on the pedagogical value of using software in mathematics:

EXCERPT 7:

> *At a school, after a lesson (a show) with sketchpad on the trinomial: A 15-year-old pupil says to a peer: "Hey, is this maths? He (the teacher) was pushing some buttons and there was a curve which went up, down, then became blue, red, thin, thick…it was fun". I leave the comments to you.*

Using the form of a "self explanatory" small narrative, this student reacts to previous posts of her colleagues.

Discussion

The results from the preliminary analysis are of an indicative character and can by no means give clear or definitive answers to the issues posed by the research questions. However, in terms of identifying the kinds of discourse cultivated in the class blog, and the changes in roles and practices, the analytical categories used have aided in clarifying certain emerging patterns. The most significant seems to be that of the informal discursive style, and the effort of participants to engage in communicatively demanding situations, avoiding some of the conventions of the mathematics writing style they are acquainted with through their schooling and university experiences.

With regards to the discourse developed, when assigned to answer open-ended questions addressing their views on their subject and its pedagogy, teachers use the explanatory and expository genres, to outline personal judgements and develop arguments. These writings show a structured cognitive presence, as teachers enrich the discussion with a combination of factual, conceptual and theoretical knowledge. However, as they become more comfortable with blog use, and are assigned more complex tasks -such as the collaborative design (in small groups) of a teaching unit, they employ the procedural genre to describe their methods. When their work is commented upon, either by posing a question or by stating disagreement, they declare their sources and carefully describe their rationales.

Despite the employment of a variety of genres, what can be characterised as informal discursive style is mostly evident in the quite unexpected number of teachers' narratives, which cover a range of functions and extend the spectrum of Shulman's (1987) categorisation, in the sense that some of them aren't single, individual stories, but emerge collaboratively, in a time span of conversation lasting from two to three months.

With regards to the emerging forms of social interaction there has been enough evidence to indicate that mathematics teachers can engage in "warm" debate, provided with the appropriate stimuli, declaring both cohesive and interactive presence, and, in some cases, even affective. The social norms developed relate to the degree of appropriation of the blog by the teachers. Based on empirical observation carried out so far, and on the daily maintenance of the class blog, the researcher has come to identify specific profiles with certain behaviors, which have affected activity and post frequency on the blog. Their presentation as "profiles" sheds light in the ways their behaviours shaped new social roles for the students.

a) "blog enthusiasts", embracing blogs as frequent practice (posting almost on a daily basis and fervently commenting on others' entries) and expressing a vivid interest in learning more about this technology and using it in their own lessons. This group formed a minority of three students, who were supported in setting up their own blogs and are currently, after the end of the course, in contact with the researcher, so that their progress can be further recorded and studied. These cases will, at a later stage, provide answers to the research question about the "instrumentalisation" of blogs, that is, whether they can be appropriated by teachers as personal and professional instruments, even if this is not a course prerequisite.

b) "blog frequent visitors", who are inclined to visit the blog quite often, but not to comment or contribute to a discussion, but merely to print course materials or observe on going activities or debates. This category is the last to respond to a blog assignment, and present a more rigid form of written work, indicating less spontaneity and task engagement.

c) "blog skeptics", who have anonymously expressed their doubts in the questionnaires, as to what exactly this kind of activity has to offer them, but, have seemed to feel obligated to contribute, seeing their presence as a course obligation.

With regards to the change of role of the instructor, there is evidence that much of what was previously done in these courses was merely replicated through the blog, but there are also indications that the use of the tool has provoked reflection on his behalf, too. His main preoccupation is the issue of sustainability of the blogging practice, considering the technical and administrative load entailed in its implementation.

Further work needs to be completed to inform a more thorough analytical framework, providing a clearer synthesis of the initial framework to the situated elements that the specific context brought to surface, such as the role of narrative in teachers' interactions. The instruments used to pursue this aim are the quantification of data (frequency of visits and percentages of posts related to the analytical categories), the analysis of the final "blog evaluation questionnaire", addressed to the students at the end of the course, in conjunction with the observation notes and informal discussion transcripts of the researcher.

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Educational Technology and Practice: Types and Timescales of Change

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ABSTRACT
This article identifies three uses of educational technology and evaluates their potential to change curricula and pedagogic strategies. The article is in four parts, with the first outlining a temporal model of change and discussing educators' expectations of continuities and discontinuities in practice. In order to distinguish minor modifications from culturally significant changes in practice, the second part recaps a variant of Merlin Donald's cognitive-cultural theory of human evolution. The third part adopts this theoretical perspective and classifies uses of multimedia-hypertext systems, generic software, and computer modelling software, as instances of functional substitution, delegation and innovation. The fourth and final part of the article evaluates the change potential of these types of use, with substitution sustaining existing teaching strategies and curricula, with delegation modifying practice, and with innovation prompting culturally significant change. The article concludes by suggesting that functional substitution and delegation dominate present-day uses of technology and that functional innovation will continue to present both challenges and opportunities to future generations of educators.

Keywords
Curriculum change, Evolution of learning, History of education, Pedagogic innovation

Technology and Change in Practice

Will the introduction of educational technologies significantly change curricula and pedagogic practice? According to Oliver and Price, the answer to this question depends on the level of analysis (Oliver, 2006). At the micro-level, their study of teachers starting to use a virtual learning environment (VLE) found that everything changed as keyboards and screens mediated interaction with students. Meanwhile, at the mid-level of pedagogic tactics, these remained familiar even though the teachers had to change, for instance, their methods of gauging student attention. Finally, at the macro-level, strategic matters such as curriculum planning, the monitoring of student progress and the provision of feedback were sustained rather than changed by technical innovations.

A model of change through time

This article expands on the three-level analysis of Oliver and Price, and sketches a temporal model of technology-related change in practice, as shown in Figure 1. The levels of analysis are translated into three sets of nested and linked practices, where the links can be indirect, subject to delays, or weak relative to other influences.

The indicative timescales, shown in italics in Figure 1, draw on experience and the following comments on educational change at the intersections of mathematics, computing and modelling. The first comment is from Judah Schwartz who cautions against expecting teachers to make simultaneous changes in practice. At the CAL89 conference, he suggested it was unrealistic to expect staff to adopt new technologies, to change curricula, and to change their teaching strategies in a single leap. Instead, he argued for a phased approach to change, as reiterated in his chapter on 'the right size byte' (Schwartz, 1995). The second comment laments resistance to fundamental change in education (Noss & Hoyles, 1996). Here, the authors close by analysing the waxing and waning of Logo 'as a fashionable means of learning mathematics' and, following Bernstein, implicate established systems of knowledge, position and power. The third commentary is from Hal Abelson who spoke at a research seminar (Riley, 1986), where he described MIT's educational computing projects and claimed the most important contemporary developments would be those seen 'two to three hundred years ahead, as significantly improving cultural consciousness'.

Together, these comments suggest that changes in curricula, teaching strategies and technology do not come easily or quickly, hence the timescales indicated in Figure 1.

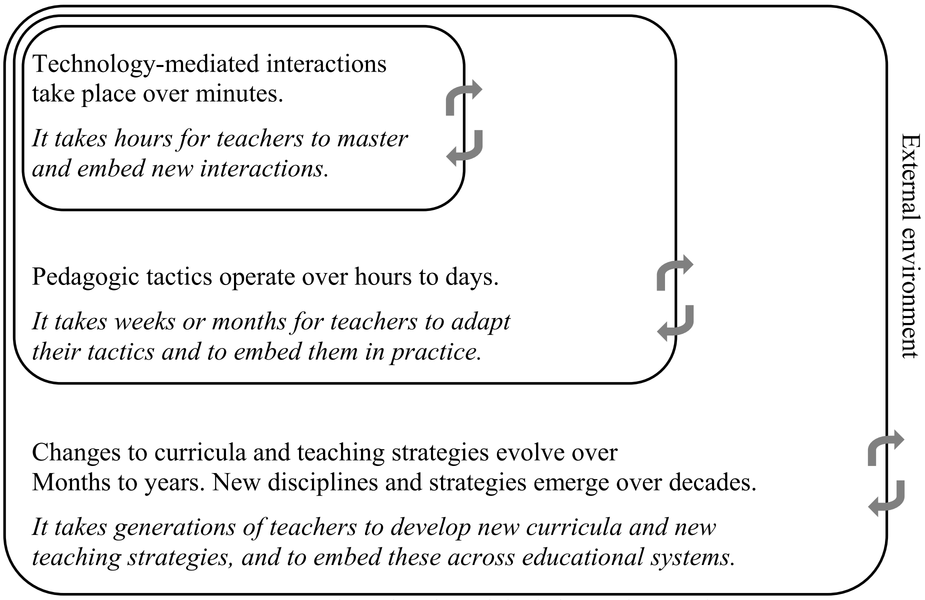

Figure 1. Three-level model of change in practice

Expectations of continuity and disruption

The model outlined above provides a basis for analysing expectations of continuity and change in practice. For example, those who expect new technologies to lead to new curricula and teaching strategies are likely to believe the three sets of practices are, or should be, closely-coupled (e.g. Papert and Strohecker, 2005). Whilst those more sceptical about change (e.g. Oliver, op. cit.), may believe the compartments operate more or less independently, and that continuity rather than change may predominate at the strategic level. A further factor to consider when comparing expectations is the timeframe, thus, a slow but prolonged change may pass unnoticed over the short-term and yet become prominent in the longer term.

Abelson's timescale of two or three hundred years reminds us that the field of educational computing, CAL or e-learning is still young; only some twenty years old when he spoke and some forty years old today (Smith, 2005). To better judge where educational technologies and practice may go in the future, we need to view our own times from a longer-term historical perspective. One such account of 'how education got here' was outlined previously (Riley, 2002a), and is recapped below before it is related to present day uses of technology, and to the prospects for long-term change in pedagogic practice.

An Evolutionary Account of Learning and Education

Several authors offer accounts of the co-evolution of human cognition and culture, including the familiar cultural forms of the performing arts, the humanities, religion, mathematics, science and technology (e.g. Mithen, 1996; Plotkin, 1997; Carruthers et al., 2002). Merlin Donald's account is adopted here as he discusses the origins of pedagogy, educational curricula and the impact of modern information technologies (Donald, 1991, 1997, 2002).

Three cognitive-cultural transitions

Merlin Donald's account of human evolution was prompted by his interest in the biological and cultural differences between our own species, present-day primates, and the inferred characteristics of ancestral apes some five million years ago. To account for the development of modern humans he proposed a theory of three major and accumulative transitions. He argues these were the minimum changes required to arrive at our present state, where we are able to act symbolically, and are able to express ourselves through body language, oral languages, and graphical or written languages.

Donald associates the invention of pedagogy with his first transition, the emergence of a 'mimetic culture' around a few million years ago (Donald, 1998). He claims the voluntary recall of memory, and the ability to control and share attention, enabled individuals to reflect on past events and to plan and rehearse for future ones.

The second and later transition is marked by changes to the brain, throat and hearing, enabling *Homo sapiens sapiens* to generate and comprehend complex speech. Donald argues that biological adaptations for spoken language took place during the last 500,000 years and led to changes in the subtlety, precision and abstraction of human thought, and to the chronological and narrative modes of reasoning characteristic of a 'mythic culture'.

Donald's third transition led to our present day 'theoretic culture', based on the manipulation of external symbols, and most clearly expressed in formal and logical reasoning. This cognitive and cultural transition was marked by the use of graphical images and written inscriptions over the last fifty to five thousand years. This period of evolutionary time has been too short for biological adaptation to occur and Donald proposes that the cognitive and cultural problems posed by inscriptions were solved by the development of lengthy educational curricula based on the '3 Rs': *r*eading, w*r*iting and a*r*ithmetic.

A fourth transition

Merlin Donald views modern information and communication technologies as important elements of theoretic culture, and believes they enhance collective memory and cognition. In contrast, two mathematics educators have argued for a fourth transition, on the grounds that computers externalise not only symbols but symbol processing (Shaffer & Kaput, 1999). Following Donald's schema of increases in cognitive capability triggering cultural change, they propose that autonomous symbol processing technologies are leading to a 'virtual culture' exemplified by computer modelling as a mode of thought and expression.

David Shaffer and the late James Kaput claimed this present-day transition generates novel educational opportunities and demands. For instance, they suggest that existing mathematics curricula aim to improve students' mental manipulation of passive images and written inscriptions, and were intended to meet the needs of theoretic culture. Curricula appropriate for a virtual culture should prepare students for a world where many computational tasks are off-loaded to machines and, where computer-based modelling is an increasingly widespread and important practice.

Technology, educational practice and the four transitions

Merlin Donald's theory, as elaborated by Shaffer and Kaput, proposes a succession of four hominid and human cultures, each of which appropriated, reinterpreted and built on its precursors. These cultures, along with the origins of pedagogy and of institutionalised education, are summarised in Table 1.

This perspective on educational technologies and practice is likely to be unfamiliar for several reasons. Firstly, the criterion of significant change in practice is cultural, in the sense of Shaffer and Kaput's transition to a 'virtual culture'. Secondly, the timescales are extremely long, compared with the life cycles of university curricula and the life cycles of educational technologies. Thirdly, computer modelling is given prominence, despite being relatively rare in practice (Laurillard, 2002; Riley, 2002b). Finally, the metaphor of orchestration is introduced, to stand for the mediated manipulation of symbols in computer models. Orchestration is used here, as an alternative to 'instruction', because of objections to this term in the earlier conference presentation (Riley, 2005). The first objection came from participants who viewed learning as a process of construction, and argued the didactic associations of 'instruction' were distracting. The second objection, from an empirical modelling perspective (Beynon, 2007), was that 'instruction' had particular connotations in conventional computer science and these were best avoided.

Three Idealised Uses of Educational Technologies

This part of the article adopts Shaffer and Kaput's cognitive-cultural perspective and identifies three idealised, or canonical, types of use of educational technologies. In the final part of the article, these three types will be related to current practice and the prospects for culturally significant change.

Table 1. An evolutionary perspective on learning and education

Type of culture	Cultural agents, and new forms of practice	Associated developments in learning and institutionalised, formal education
Episodic	Apes act skilfully within 'episodes': no conscious use of symbols or voluntary recall of acts outside of these episodes.	Individuals learn by instinct and some mimicry. Minimal group and inter-generational learning, and extremely slow rates of cultural change.
Mimetic	Hominids invent body language and act symbolically: dance, gesture and mime. Performing arts and pedagogy emerge.	Individuals learn to recall, reflect, rehearse, and coach. Two-way, 'tutor-tutee' interactions are invented and the beginnings of pedagogy facilitate social and cultural change.
Mythic	Early humans invent oral languages: sing, speak and narrate myths. A wide range of social-cultural practices emerges and is elaborated.	Our species adapts biologically and individuals learn to think chronologically and abstractly, to teach with and about language. Narrative invention, rhetoric, and abstraction drive learning and accelerate cultural change.
Theoretic	Humans invent written language: draw, inscribe, write, count and compute. Agriculture, art, commerce, defence, education, governance, industry, law, mathematics, medicine, philosophy, religion, science and technology develop as complex specialisms and culturally inter-related practices.	People adapt culturally (not biologically) and learn to use external symbol systems, to master specialist discourses and practices. The '3 Rs' entail lengthy tuition, and specialist fields require subsequent apprenticeships. Specialisation, made possible by long periods of 'cloistered' formal education, reinforces and accelerates cultural change.
Virtual	Humans invent computer modelling languages: construct and investigate models, treat them as expressive devices and sources of knowledge. Models act as mimetic agents: move or gesture, draw, compute, read, write… and respond to other agents. Computer science, informatics and new forms of mathematics emerge and, influence other disciplines and specialist practices.	People learn to 'orchestrate' external symbols using computer models, to enter discourses and practices of *indirect* symbol processing. O*r*chestration, the '4th R', is appended to existing curricula and new curricula emerge, e.g. in genetic and biological engineering. Three-way, 'tutor-tutee-computer' interactions are invented and extend existing pedagogies. The '4th R' and three-way pedagogy impact on human learning and cultural change.

Functional substitution

The first type of use of educational technologies, called 'functional substitution', is associated with typical uses of multimedia, intranets and Internet technologies. These technologies and their derivatives are widely used in higher education and, in part, substitute for previous media. One can imagine, for example, that a Palaeolithic cave-artist or ancient Egyptian stonemason would marvel at streamed video but, they would comprehend the intent. Similarly, a Sumerian cuneiform scribe would recognise the pedagogic purpose of an online written task in accountancy, commerce or law.

Functional substitution sustains the exchange of images and inscriptions between students and teachers, a practice inherited from theoretic culture and based on ancient pedagogic roles and rhythms. When students and teachers use online discussions, Weblogs, Wikis and multimedia depositories, the underlying computer technology is meant to remain invisible or 'transparent', and traditional two-way, tutor-tutee relations are maintained. Similarly, it is proposed that changes to curricula are more likely to be superficial than fundamental, when 'old wine is transferred to new bottles'.

Functional delegation

The second type of use of educational technologies, called 'functional delegation', is commonly associated with word processors, spreadsheets, databases and other generic software. These technologies are widely used in higher education and enable people or 'users' to delegate routine symbol processing tasks to computers acting as agents or clerks. For instance, teachers may use VLEs in this way to track low-level student 'attendance', to record performance on quizzes and to provide conditional feedback on their answers. The teaching of computer science and cognate fields is an exception here, as the technology is a sustained focus of attention for these students.

For most students and teachers, functional delegation involves the passing of symbol-processing tasks to computers. The computers are responsible for the execution of clearly defined tasks whilst students and teachers are responsible for selecting or specifying the appropriate algorithms. Thus, functional delegation introduces a triangular relationship between the teacher, student and computer although the latter is assigned a subsidiary role. Functional delegation leads to new 'skills' being added to curricula but, with the exception of computer science and closely related fields, curricula remain much the same as before.

Functional innovation

The third type of use of educational technologies, called 'functional innovation', is epitomised by computer modelling. A symbolic model can serve as a way of thinking, a means of expression, and a subject of investigations, although it differs in kind from the subject of a scientific experiment or a device in an engineering test rig. A model can play a key and sustained role in student learning with a three-way, if unequal, relationship between teacher, student and computer. Learning to model also may lead to a '4th R', as outlined in Table 1, and prompt significant changes across a wide range of disciplinary curricula as people put their 'heads and computers together'.

To understand what functional innovation may mean in education, take the parable of Daisyworld as an example (Watson & Lovelock, 1983; Lovelock, 1988). Lovelock's Daisyworld simulations demonstrate the reasoning and systems principles underpinning the Gaia Hypothesis and illustrate the expressive possibilities of computer modelling. Versions of these models have subsequently been reproduced in environmental science texts for students to investigate, elaborate and discuss for themselves (e.g. Ford, 1999; Hardisty, et al., 1993; Henderson-Sellers & McGuffie, 1987).

One reason why it is difficult to describe the character and scope of functional innovation is that it amounts to cultural work-in-progress. We are yet to develop adequate terms, discourses and shared understandings to explain its features and applications. For instance, commentaries on professional practice yield a range of views on what computer modelling is, and what modellers do (Dowling, 1999; Galison, 1996; Morgan & Morrison, 1999). Similarly, commentators on learning by modelling imbue their books and papers with a sense of unfinished business and of history in the making (DiSessa, 2000; Mellar et al., 1994; Noss & Hoyles, op. cit.), or of a present with roots in an ancient past (Roth, 2001).

Reflections on the three uses of technology

The three types of use of educational technologies are idealised and do not map onto particular tools or combinations of practices. For instance, a teacher using a VLE may engage in a series of written interactions with students (functional substitution), and set an online quiz with conditional feedback (functional delegation). Or, a student might use a spreadsheet to record and graph experimental data (functional delegation), and then extrapolate the results by creating a statistical or causal model (functional innovation).

The three types merely serve to discriminate between uses of technologies which align with the 3Rs and the two-way interactions of theoretic and earlier cultures, and uses which align with the 4th R and the three-way interactions characteristic of virtual culture.

The Prospects for Culturally Significant Change

This part of the article relates the three idealised uses of technology, and the earlier model of temporal change, to the prospects for significant change in educational practice.

Functional substitution is interpreted as being culturally conservative. There is continuity in the strategic mission of sharing learning between individuals, groups and generations. In accordance with Oliver's comments, these types of use of technology maintain and replicate familiar pedagogic strategies and curricula, even if the specific, technology-mediated acts are new. The roles of tutee and tutor remain much the same and their interactions follow ancient dual and dialogical beats.

Functional delegation for most students and teachers introduces changes or reforms in pedagogy at a tactical and curricular level, as illustrated by the introduction of courses in 'IT skills' over recent decades. Previous generations of students and teachers did not possess autonomous symbol processing agents or have to learn how to harness their capabilities. Thus, functional delegation introduces a three way pedagogic relationship but the computer plays a subsidiary role and does not fundamentally change disciplines or their core curricula.

Functional delegation has a more radical impact on teaching strategies and curricula in computer science and related fields, where new disciplines and curricula are being generated over timescales of decades. Beynon is better placed to comment on this (Beynon, op. cit.), although it is tempting to speculate that the instrumental use of computers to perform tasks characteristic of theoretic culture, may map onto his dominant conception of computation. Empirical modelling and an alternative conception of computation may better map onto the notion of functional innovation.

Functional innovation, typified by computer modelling, could lead to significant change both because of its three way pedagogic interactions and its cultural novelty, which may translate into a 'fourth R' in educational curricula. However, making sense of modelling remains a challenge to professionals and commentators (e.g. Keller, 2002; McCarty, 2005), and to teachers and students. For example, as O'Sullivan asks in relation to complexity:

> "How models may be used to learn about the world – if at all – is a critical epistemological question."
> (O'Sullivan, 2004).

Functional innovation, as envisaged here, encompasses the educational ambitions of previously cited educators such as Shaffer and Kaput, and Noss and Hoyles. Their comments on computer modelling could be interpreted as a call for a new form of mathematical literacy, a view that resonates with the ideas of DiSessa. However, these ideas and practices are emerging slowly, and the timescales of educational change may be measured in generations of educators rather than in decades.

Do the temporal model and functional types match recent history?

Abelson's proposed time span of two to three centuries would support a reasonable evaluation of the model of change and the three types of use. The best we can do now, however, is to compare the model against the available forty-year history. So, one might argue that if the model is sound, then functional substitution should have dominated in the early years with functional delegation appearing next and functional innovation being the latest to emerge, if at all.

Paradoxically, personal experience suggests the reverse pattern. Computer simulations, games and modelling software were prominent amongst the supply-led developments of the 1970s and 1980s, well before the appearance of multimedia and the Internet. So is this judgement of the forty years flawed, or is the model of change faulty?

A sound historical judgement would require research beyond the scope of this article but the model of change can be defended on the grounds that the computers of the mid-1960s to 1980s lacked the memory, processing power, storage capacity, display and communication capabilities to support functional substitution. The technologies needed to become more versatile, cheap and pervasive before the use of multimedia systems and the Internet could flourish in education.

This reading of history suggests there were technical reasons, amongst others, for regarding the first twenty years as anomalous in the mix and balance of the functional uses of educational technologies. The take-up of educational technologies over the second twenty years may be a better indicator of institutional priorities and of practitioners' preferences and of demand-led developments in the coming decades. Viewed from this perspective, it appears that functional substitution, delegation and educational continuity will prevail for some time to come, whilst functional innovation takes a slow-burn revolution over much longer timescales.

Prospects

This article has adopted an evolutionary perspective and discussed a temporal and functional model of technology-related change in educational practice. It concludes by supporting Oliver's contention that much remains the same when educational technologies are introduced into higher education, thanks to historical or even pre-historical momentum. At the same time, the first inklings of significant change are emerging and offer opportunities for present and future generations of educators to make pedagogic history.

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Computing technology for learning - in need of a radical new conception

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ABSTRACT

Many have had high expectations for the impact of computer-based technology on educational practice. By and large, these expectations have not been realised. It has become evident that innovative technology alone does not necessarily guarantee progress - nor perhaps even significant change - in educational practice. This has led educational researchers to place greater emphasis on cultural issues that could account for the unexpectedly limited influence of technology-enhanced learning. This perception of the relationship between technology and learning is elaborated in the first section of the paper. It is complemented by a review of an alternative conception of computing, rooted in a methodology for modelling with dependency directed at the development of *construals* rather than programs, that is far better aligned to the demands of developing environments for learning. The paper concludes with a discussion of the potential implications of this approach.

Keywords

Educational technology, Learning, Constructionism, Dependency, Construal, Modelling, Computing

Introduction

In accounting for the limited impact of digital technology upon education, attention has shifted from the technology itself to the cultural context surrounding technology-enhanced learning. Education, like other areas of computing application, has endured too much hype to be sure of the contribution that further technological innovation can make to advancing educational practice. The best insights into how learning takes place all motivate a broad view of the educational context embracing psychological, social and political agendas.

Against this background, it may be surprising that this paper concerns a new approach to computer-based modelling, conceived within computer science, that has involved developing new software tools. To appreciate this as more than 'yet another technological innovation' involves recognising the deeper pretension behind this approach. Whilst strategic research interest in educational technology has shifted away from the technological perspective (witness the disqualification of 'technology-led' proposals from recent EU calls relating to Technology Enhanced Learning (Manson, 2004)), this paper argues for a radical reappraisal of the role of computers in learning based on alternative principles and practice for computing. Its thesis is that the accepted conceptual framework surrounding computing technology is critically ill-suited for creating environments for learning. Moreover, this conceptual framework has such an intellectual pedigree and authority, and such integrity when applied within its proper remit, that it has exercised a powerful and pervasive influence over our conception of human cognition, with far-reaching implications for business and education.

Rethinking computing technology

Whatever remains controversial in technology-enhanced learning, any technology that can truly assist learning must clearly stand in a very intimate relationship to human cognition and action. By this criterion, information and communications technology, as presently conceived, is ill-equipped to engage with the universal and profound issues encountered in human learning. What is required is a perspective on computing that integrates human understanding and interaction with the development of artefacts and systems in a dynamic and holistic manner. For sound historical reasons, the fundamental conceptual framework for computing that informs the development of software and the analysis of broader computer-related activities is oriented towards a quite different agenda - achieving functional efficiency, typically through automating human cognition out of the loop.

How computing technology is *conceived* may seem to have less practical relevance than how this technology is developed and applied. Yet Papert asserts - with feeling: "Wild imagination, passion, being close to nature, and believing in magic ... I think these are all elements that we need to bring into the otherwise cold version of use of computers called 'ICT' ..." (Papert & Strohecker, 2005).

The lack of "magic" attending ICT is symptomatic of a more general and influential trend towards demystifying human affairs. In this connection, it is instructive that the primary proposal for countering the lack of excitement, mystery and imagination in the ICT curriculum (Lovegrove & Round, 2005 p.11) is to provide suitable materials, "concentrating on people and inventors, ideas and concepts, and applications of computing in everyday life (e.g. 'how your mobile phone works', 'how Google works', etc.)". There is a pertinent contrast with the mysteries of traditional science, which relate to unidentified phenomena and processes that are imperfectly understood. The meanings that classical computer science is best equipped to handle exclude such exalted concepts of ignorance and mystery - they are framed with reference to formal symbols whose identities and associated values must be made explicit, and to processes that follow prescribed algorithmic rules. Received understanding about computing involves exploiting what has already been learnt, rather than engaging with what is unknown, un-mastered or *as of now* being learned.

The accepted conception of computing technology is not only pertinent to the pervasive applications of computers; it has also exercised an exceptionally powerful influence over our whole conception of human activity. The tacit practical effect has been to privilege "rationalistic" notions (Winograd and Flores, 1987) like preconception, planning, formal languages, abstraction, methods, recipes, logic and rules *as if* they were the primitive ingredients of all human behaviour. In the process, activities that are of enormous significance in relation to human learning, concerned with creation, invention and "wicked problems" (Lansdown, 1987) in art, craft and design, and with experiment, discovery and "blind variation" (Vincenti, 1993) in science, mathematics and engineering, have been marginalized - or bowdlerized - in the educational and political discourse. Significantly, in such activities, it is not human ingenuity that primarily invokes a sense a mystery, but the subtlety of the phenomena and experiences that defy expectation and explanation.

The contemporary influence of computer science thinking on education is hybrid. The authentic intellectual legacy of Turing's remarkable characterisation of algorithmic thinking has spawned cognitive models based on a computational philosophy of mind. The limitations of the mind-as-machine metaphor as a foundation for theories of learning are now well-recognised. For instance, in *Acts of Meaning* (Bruner, 1990) - as paraphrased by an anonymous reviewer - the distinguished educational psychologist Jerome Bruner "elaborates on the failure of cognitive science in abandoning 'meaning-making' for 'information processing', and its attendant concentration on computational logic."

A key motivation for seeking a new conception of computing technology is that - whilst the authority of the classical theory of computation in studying and reasoning about algorithms is beyond question - the complementary aspects of computer science, concerned in particular with the problems of developing reliable, large or adaptive software, have by comparison most controversial credentials. These problems are moreover intellectually intimately connected with learning - they relate to human activities that precede the clarification of concepts, the identification of mechanisms and the comprehension of systems, and in general involve complex personal and social interaction between designers where issues of inter-subjectivity and conflict have a significant role. Though technologies such as objects and patterns have proved effective in certain contexts, the major limitations of current principles and techniques for general software development are well-documented (Brookes, 1987; Brookes, 1995). Significantly, development strategies involving objects and patterns are principally concerned with exploiting prior knowledge of application domains, and re-using artefacts and methods, rather than the more primitive and fundamental issues surrounding their initial construction.

In an educational technology context, more is required of a new conception of technology than a further contribution to the critiques of the 'rationalistic' traditions of computer science and artificial intelligence (e.g. McDermott, 1987; Winograd & Flores, 1987; Smith, 2002). The primary motivation is the practical development of useful software products to meet educational needs. Software development has long been centrally concerned with ways of circumventing the problems of premature specification and uncertain knowledge. The recent adoption of eXtreme Programming (XP) approaches (Beck, 1999) has sought to manage software production so that implementation and testing are prominent from the outset and the design is elaborated incrementally with no overriding initial preconception. The objectives of XP are well-aligned to those of constructivist learning: the developers aim to learn about the application domain and the user requirements in and through the process of developing a software product.

The key problem considered in this paper is that the fundamental conception of a computer program and the modelling apparatus surrounding traditional software development (in whatever idiom) offers very limited support to the discourse of primitive learning. From an educational perspective, the significant distinction is that between *representing* and *construing* identified by Mason (1987). Representing involves establishing conventions for associating formal symbols with entities; construing involves giving an account of the experiences that inform personal understanding.

In the traditional conception of computing, the separation between those elements admitting mathematical formulation and the informal experiential aspects is seen as sharp. Making computer representations involves committing to specific interpretations that cannot be revised in execution of the program or system. Human learning activity, in contrast, often begins in confusion, and may involve the reappraisal of interpretative conventions even as they are being employed. A major challenge in deploying computer technology in support of constructivist learning is that traditional representational principles do not accommodate new modes of interpretation that emerge through interaction with a computer artefact, nor support the high degree of integration of learner, teacher and developer roles that learning-by-constructing ideally presumes. Commitment to interpretations and goals is the price traditionally paid for optimization, and incurs notorious inflexibility when changing requirements. This is particularly relevant to educational software; because of the extreme variation in learner characteristics and capabilities, the most subtle changes in requirement are of the essence.

A radical new conception of computing technology

This section outlines a programme of research into a new conceptual framework for computing being pursued by the author and his collaborators. *Dependency maintenance* is the key technology we exploit. *Dependency* is familiar from spreadsheets, where an update to one cell leads to other cells being updated as if in one operation. Our previous research, spanning some twenty years, has elaborated on spreadsheet principles, and explored applications to many areas in addition to educational technology (For more background, consult the Empirical Modelling website at the Empirical Modelling website: http://www.dcs.warwick.ac.uk/modelling).

The general principles behind our modelling framework are briefly reviewed in the context of related research that has exploited dependency, and illustrated with reference to three modelling exercises.

Dependency in software construction

Dependency features widely in software. It is most conspicuous in spreadsheets for handling quantitative data, but spreadsheet principles have been applied to modelling scientific data and extended to support data visualisation. Functional dependencies are fundamental to relational database design, and in defining views. Dependency is exploited in modelling software for engineering and business, such as LabVIEW (National Instruments website: http://www.ni.com) and Attribute Explorer (Spence, 2000), where graphical representations are automatically maintained to be consistent with the underlying data. The potential role for dependency in interface design has been demonstrated in software such as Amulet (Myers et al, 1997). Abstract forms of dependency underpin concepts such as 'object linked embedding', style definitions in word processors and make utilities for complex software maintenance. Dependency analysis is now being deployed in applications such as maintaining large websites, and reducing the storage required to record the accessible assets in computer games (Carter, 2003). This has motivated the development of principles to support dependency maintenance within an object-oriented programming context (e.g. Perry, 2001). Dependency features prominently in mechanical devices developed for representational purposes prior to the modern computer, and is intrinsic to the analogue devices that pre-dated digital computers (Small, 2001).

In applications, dependency often serves a characteristic cognitive function of imitating relationships between external observables that help the modeller to recognise the intended meanings of variables and components within a model. For instance, there is direct correspondence between interactions with an examination spreadsheet and the way that the average mark on an examination paper is affected by discounting the absentees. This highlights the significant role for dependency in making computer models meaningful, and underlies the numerous applications of spreadsheet-related principles in education (Baker & Sugden, 2003), particularly - with constructionism in mind - in relation to end-user programming (Repenning, 1993). The use of dependency to which this paper specifically refers is intimately connected with ensuring that the meaning of a model can be directly apprehended by the human interpreter, and relies upon principles that are not in general respected where dependency has been used in an *ad hoc* manner, or exploited merely as an abstract programming device in conjunction with conventional programming techniques. These principles define a methodology for model-building to which our use of the expression *modelling with dependency* refers.

Our methodology for modelling with dependency

Our applications of dependency in model-building rely upon a particular methodology for domain analysis. In this methodology, the modeller acts in a role resembling that of an experimenter applying the 'scientific method'. Model construction is incremental, and evolves along with understanding of the domain that emerges through identifying patterns in interaction within the domain. These patterns are expressed in terms of key *observables*, *agents* deemed to be responsible for changes to these observables, and *dependencies* reflecting the way in which changes to observables are linked. The construction of models that embody the emerging patterns of observation, dependency and agency is supported by special-purpose notations and tools.

The motivation behind our methodology is that - if we are to support learning in cognitive terms - our construction of software should be informed not merely by a narrow requirement, but - to the fullest possible extent - by domain understanding. In our modelling framework, this translates to "identifying the most appropriate way to conceive interaction within the domain with reference to the agents that we deem to be acting, the observables that we deem to mediate their interaction, and the dependencies that we deem to govern the synchronisation of changes to observables". For brevity, this is termed "identifying the most appropriate *construal* of interaction within the domain". Modelling with dependency is then interpreted as 'building construals' (cf. Gooding, 1990). The soundness of our methodology rests upon the thesis that such construals are an appropriate way of expressing fundamental understanding of domains of interaction.

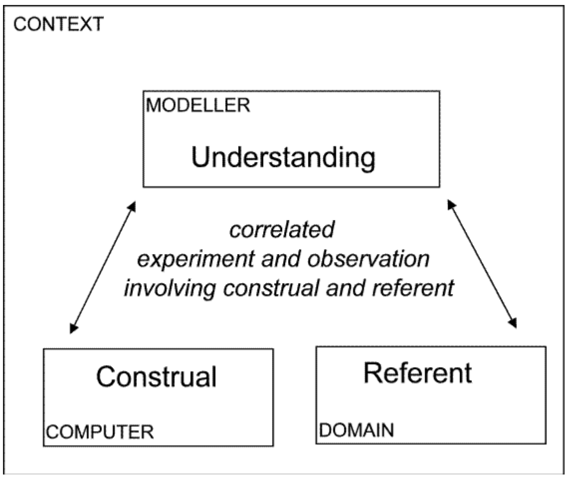

Figure 1. The archetypal setting for modelling with dependency

Our thesis about domain understanding informs a distinction between modelling with dependency and computer programming (as traditionally formally conceived). A program constructed merely to achieve a specific functional goal, does not - in general - require a deep construal of interaction in the domain. However, such a program will be unhelpful - if not obstructive - if new requirements or insights must be taken into account. There is only a loose and complex relationship between the separate concerns of developing deep understanding of domain interaction and devising effective recipes to solve specific problems.

Practical principles for modelling with dependency

Modelling with dependency relates to an archetypal setting for interaction (see Figure 1). The modelling activity depicted in Figure 1 is to be viewed from the perspective of the modeller, who has direct immediate personal experience of an artefact that has been generated using computing technology ("their construal") and of some independent situation, phenomenon or more ill-defined focus of attention to which the artefact refers ("the referent"). At any moment, the modeller experiences the construal and its referent in just one of their many possible states. The modeller stands in the role of an experimenter who can perform state-changing actions on both the construal and its referent, and may also be able to configure them in context to exhibit some autonomous behaviour. The construal serves to mediate the modeller's understanding of its referent. This understanding stems from familiarity with interaction with the construal and referent that is attested by recollection of past patterns of interaction and reliable expectations about the consequences of future interactions. There need be no formal basis on which the construal relates to understanding of the referent. The presumption that guides the modeller is that the correlation between the current state of the construal and that of its referent can itself be experienced. The modeller aspires to bring about this state of affairs through engineering the context, making the construal, identifying the referent, and rehearsing interactions.

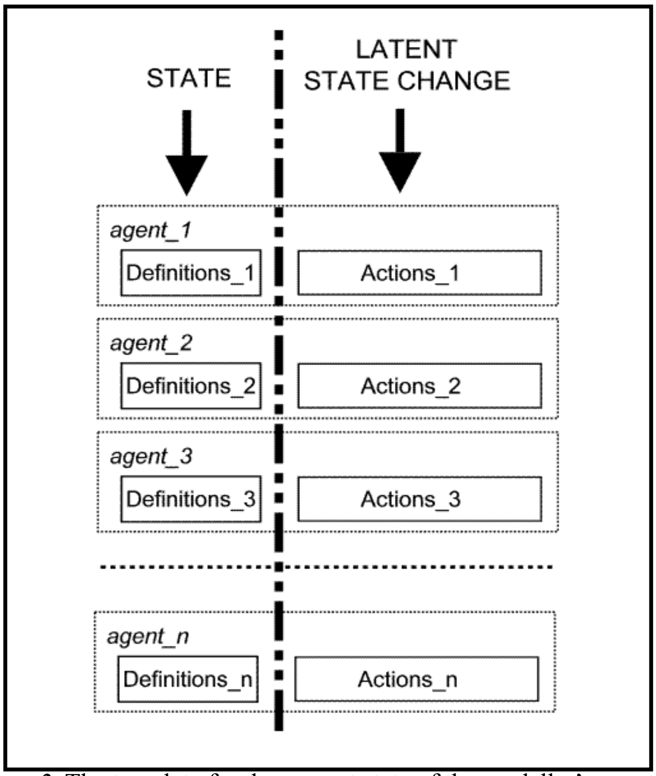

Figure 2. The template for the current state of the modeller's construal

As a familiar example, the modeller may be constructing a spreadsheet to reflect their personal financial situation. Simple as this example is, it illustrates many of the subtleties of the semantic relation between construal and referent and of the modeller's role in shaping this. For instance, interaction with the spreadsheet may be solely concerned with tracing prosaic transactions on an account. Alternatively, it might involve forecasting for a fictional future scenario. It might entail simulation of future financial circumstances over an extended period of time, perhaps with opportunistic intervention by the modeller aimed at accounting for expected but unquantifiable bonuses. Other extensions of the spreadsheet might involve extending the semantic range of the spreadsheet - dividing income into categories or reprogramming to accommodate changes in tax law. Note that the role the spreadsheet plays in mediating understanding is contingent upon tacit constraints on the modeller's interaction. Relevant issues include: *What are extreme values for an exchange rate? What components of income are not taxable? Does it ever make sense to base a computation of profit on the square of the income?* The depth of understanding that can stem from such modelling depends upon how much discretion the modeller has over the context. From an educational perspective, the scope for using such a model as a "learning artefact" is diminished essentially if - in the spirit of traditional programming - constraints upon interaction are formalised, rendered explicit and imposed. Nor is it appropriate to regard the modeller as merely a 'spreadsheet user', since the interactive possibilities encompass significant and fundamental redesign.

In conceptualising the spreadsheet as a construal, both the dependency relations between cells and the visualisation and annotation of values within the grid are vitally important. The use of dependency can usefully transcend maintaining relationships between scalar quantities, as when negative quantities are displayed in red, or the spreadsheet is dynamically linked to a chart. Our framework supplies generalised support for modelling with dependency by enabling the modeller to formulate spreadsheet-style definitions linking the values of observables of a diverse kinds. For instance, definitions can connect scalar quantities with locations, attributes and textual annotations associated with drawings and screen displays. As in a spreadsheet, no explicit program code is required to ensure that the associated dependency relationships are maintained when values change. A family of definitions serves to express the state of the modeller's construal as it is currently presented for ongoing observation and experiment. A typical primitive interaction by the modeller involves modifying, adding or removing a definition. The semantic significance of such an interaction need not be preconceived - it may involve a "classification of experience" to be negotiated according to the modeller's intentions and conception of the context. Where the referent is perceived as acting autonomously, certain groups of observables may be viewed as ‘agents’ whose actions can be expressed as sequences of redefinitions and/or invocations/dismissal of other ‘agents’. A typical agent action then takes the form of such a sequence together with an appropriate cue for its execution, expressed as a relation between observables to which the agent can respond.

The idealised template for the current state of the modeller's construal in modelling with dependency is depicted in Figure 2. The association of definitions of observables by agents at first merely reflects the integrity of clusters of observables that are perceived to co-exist, being invoked and dismissed together. The actions associated with such a family of definitions are interpreted as actions attributable to the agent, and are subject to be performed automatically. In Figure 2, the set of actions or definitions associated with an agent may be empty if it is construed as having no capacity for state-changing action or significant observables. In principle, the modeller is free to modify, add or remove any definition whatever at any time, and such an action is meaningful in so far as it respects - or informs - the relationship between the construal and its referent.

Some illustrative examples

The above overview of the principles of modelling with dependency will be complemented by a brief description of how they are applied in the three modelling exercises. (For more details of each of these exercises, consult the online posters at the Empirical Modelling archive: http://empublic.dcs.warwick.ac.uk/projects; kaleidoscope, n.d.).

The JUGS model: The JUGS model was first conceived as a generic basis for developing variants of a simple educational program for a range of different computing platforms (Beynon et al, 1988). The original program simulated the actions of filling, emptying and pouring liquid between two containers ("jugs") of integer capacity. The program was designed to support a mathematical investigation into what quantities of liquid could be generated in this fashion (as is in fact determined by the highest common factor of the capacities of the jugs). The visual form of the JUGS construal is quite simple - each jug is represented by a textual pattern to represent the outline of the jug on which is superimposed a display window of variable height to represent the liquid content. This display is complemented by a set of buttons for performing “fill”, “empty” and “pour” operations whose responsiveness and display status depends upon the availability of these options. In relation to Figure 1, this construal can be interpreted either as referring to an actual pair of containers of appropriate sizes, or as giving concrete visual expression to abstract numerical quantities. With reference to Figure 2, the jugs themselves are passive agents that are represented by a family of definitions that express the dependencies between observables such as the capacities and contents of the jugs, the geometric characteristics of their display, and the status of the menu options. These passive agents are complemented by agents associated with the menu options whose actions are cued by the corresponding button presses. The JUGS construal is quite different in character from a typical program to realise the narrow functional specification implicit in its button interface. This is decisively demonstrated by the wide range of alternative technical and semantic purposes to which it can be readily adapted. Interaction with the construal illustrates how the notion of a container being *full* is context dependent, for instance. The construal can also be used in conjunction with alternative interfaces, adapted for more precise and realistic representations of liquid and containers by taking leakage and evaporation into account, and extended to explore such representations within the engineering limits of the screen display. By acknowledging the possibility of radically different alternative views of the context and referent (cf. Figure 1), the underlying observables and dependencies can also undergo a metamorphosis whereby variants of the JUGS construal derived through relatively few redefinitions can refer to persons queuing at a bar, or to the strings and frets on a guitar (For more background, see Beynon et al, 1989; EMarchive:jugspresentationKing2005.).

The Clayton Tunnel model: This model illustrates how the principles of modelling with dependency can be applied to multi-agent simulation that is realised on a distributed network of workstations. The model serves to animate railway operation in the vicinity of the Clayton Tunnel in 1861. The construal in this case is directed at gaining a better understanding of the events that led up to a serious railway accident. The definitions and actions associated with the various agents (cf. Figure 2) reflect the realistic possibility that different agents have different perceptions of the "same" observable. The construal also incorporates a putative "objective" view such as might be attributed to an external observer. The model is a rich source of insight into the fundamental issues that surround reconciling subjective agent perspectives with an objective reality (For more background, see Beynon, 2005a.).

The Erlkönig model: This model was developed to illustrate the potential for applying modelling with dependency in the humanities. The model expresses one possible way of giving visual and dynamic expression to Schubert's treatment of classical harmony in his famous setting of Goethe's ballad Erlkönig. Dependency is used to associate a node in the cycle of keys and a colour (as determined by the current key) with each moment in a performance of the song. The pattern of the harmony throughout the song is displayed in the form of a ribbon of colour. Because the way in which Schubert exploits harmony is open to critical human interpretation, there is no convergence to a canonical interpretation, but an essential openness to revision and critique. This undermines the notion of the model maker as merely an objective observer of a system behaviour - the role of the modeller in relation to the behaviour of model is instead somewhat analogous to that of the performer (For more background, see Beynon, Russ, McCarty, 2006; Beynon, 2006b.).

Potential implications of modelling with dependency

Modelling with dependency is associated with a radically different conception of computing. It involves a reorientation that goes beyond developing a new programming language or even a new programming paradigm. In the terminology of the humanities, it entails "deconstructing" the notion of program, and initiates another "discourse".

Key characteristics of modelling with dependency

The conceptual core of current thinking about computing is concerned with controlling and predicting the corporate behaviour of agents whose capabilities for state-change and interaction are highly reliable, with its associated contextual overtones of system-like character and objective external observation. Even in areas where experiential aspects take precedence, as in research on artificial life, micro-worlds and simulation environments, or in applying alternative development techniques, such as genetic algorithms or neural nets, the computational focus is on crafting behaviour. The underlying metaphor for the interactive computer artefact is the machine or system, and the associated notion of human-computer interaction reinforces the divisive duality inherent in programming. In this - even though they express an aspiration to integrate human and computer activities - the notions of 'user-centred' and 'learner-centred' design are complicit. And whilst there is considerable interest in conceiving human interaction with technology as *process* (e.g. Warboys et al, 1999) and *narrative* (e.g. Turner, 1996; Papadimitriou, 2003) rather than formal symbolic communication, such abstractions also target behaviours.

Modelling with dependency, by contrast, puts the primary emphasis on the situation as experienced by the modeller. The modeller's subjective understanding of the situation is mediated by observation and interaction. Where appropriate, behaviours emerge as patterns of interaction that prove to be predictable within a contrived context, and some of these may be objective in that they can be executed by an external agent and can appear to be independent of the observer.

Within the symbolic frameworks of orthodox computer science, the difficulty of shifting the focus from 'behaviour' to 'situation' is illustrated by the problematic status of database theory (Ridley, 2003). In modelling with dependency, this difficulty is addressed by giving priority over any symbolic interpretative framework to the semantics associated with the modeller's direct experience of interaction. To illustrate how this semantics is invoked, imagine that all annotations by way of names and identifying labels were removed from a spreadsheet constructed for some familiar purpose, such as recording examination marks. Interaction with the spreadsheet would still enable us to identify the intended meanings of the rows, columns and cells through experiment, by observing how changes to certain cells affected the values of others according to certain patterns. Such identification might even be possible if the cells of the spreadsheet were randomly relocated whilst preserving their interrelationship. In effect, provided that the dependencies between its attributes are appropriately captured, a meaningful artefact can be presented simply by exhibiting any one of its possible characteristic states and allowing the human interpreter to change attributes freely. In this way, semantic connections are potentially being made and appraised live, here and now.

The appeal to semantics that is fundamentally rooted in direct correlation of immediate experience distinguishes modelling with dependency from other non-symbolic approaches for which the ground of knowledge is more ambiguous. Modelling with dependency resembles the grounded experimental activities that a scientist conducts prior to developing a theory, and that craftsmen and engineers perform outside a formal framework for understanding. By its nature, far from being an abstract transcendental concept, dependency is a matter of private experience conditioned by the performance and interface characteristics of the underlying hardware, the sensory, interpretative and manipulative skills of the modeller, and the specific context for the experimental interactions. As discussed in (Beynon, 2005b), this is consistent with the key tenets of a "philosophic attitude" espoused by William James (1912):

> *Knowledge of sensible realities ... comes to life inside the tissue of experience. It is made; and made by relations that unroll themselves in time. (p56)*
>
> *... the "truth" of our mental operations must always be an intra-experiential affair. (p202)*

Modelling with dependency applied to learning

The ontological distinction between modelling with dependency and traditional programming parallels the two research strands of 'learning and knowledge' and 'learning and cognition' alluded to by Manson (2004). This can be seen as reflecting the tension between what Brödner (1995) identifies as the 'open development' and 'closed world' cultures in engineering. In spirit, modelling with dependency has much in common with Vincenti's (1990) vision of engineering as an epistemological species distinct from applied science, where there is a role for blind variation - interaction 'without complete or adequate guidance' potentially leading to discovery.

This distinction is reflected in modelling with dependency and traditional modelling as they apply to learning. In the use of simulation tools such as STELLA to model systems dynamics (Doerr, 1996) or ScienceWare's Model-It tool (Soloway et al., n.d.), for instance, the computer serves to animate a behaviour determined by specifying relationships and setting parameters. Such an activity could only be regarded as "modelling with dependency" subject to the modeller being in some way equipped to directly apprehend the effect that changing parameters and relationships has upon system behaviour. Much mathematical modelling of complex systems by computer is in this spirit - it exploits theoretical insight for which the empirical basis is of historical rather than topical interest, as when the modeller routinely applies Newton's Laws of Motion.

The aspiration in modelling with dependency is similar to that expressed by Riley in his discussion of "learning by modelling" and "learning by making sense of computer models" (Riley, 2005a, 2005b), but the nature of the models - as construals rather than programs - is much better suited to realising the degree of subtlety and universality that is envisaged in the "virtual culture" he invokes. The informal and provisional way in which a model derives meaning from the human interpreter's immediate experience of its contextualized state contrasts with the way in which the formal semantics of computer programs is expressed with reference to comprehensive state spaces and behaviours. This makes it possible to create environments in which to explore subjective understanding, and embody tacit and pre-articulate knowledge. It also serves to situate the accepted conception of computing in a richer context of human computer interactions, where 'concepts', 'languages' and 'systems' are emergent rather than primitive. This supplies the appropriate setting in which to tackle questions, identified by Doerr (1996) as problematic in the educational applications of STELLA, that concern the validity of models, the appropriate use of 'stores' and 'flows', and the relationship between different representations and their cognitive implications. Perhaps more significantly, it supplies a framework within which pragmatic context-dependent answers are most naturally accommodated and justified.

On reviewing the applications of spreadsheets in education, Baker and Sugden (2003) conclude: "There is no longer a need to question the potential for spreadsheets to enhance the quality and experience of learning that is offered to students." We attribute this potential to the fact that spreadsheets serve as construals, and see modelling with dependency as promising further enhancement to the learning experience. The illustrative examples mentioned above highlight several relevant features of modelling with definitions that are best appreciated through carrying out an extended exercise and observing the ways in which a model develops over a period of several months. They include:

- support for model-building in an open unsystematic fashion, where the order in which definitions are introduced is unconstrained, and the focus of attention can range freely in developing and interconnecting different components and semantic aspects;
- provision for recording partial and provisional relationships, for recovering previous states and versions, and for refining, updating and correcting definitions retrospectively without comprehensive redesign and possibly without extensive model redevelopment;
- means to extend the semantic range of the modelling tool by introducing new types and operators on-the-fly that make it possible to interpret and maintain dependency relations between new kinds of observable.

These practical qualities have implications of particular relevance to interactive environments for learning:

As a hybrid activity guided by domain understanding as it emerges, modelling with definitions enables the blending of propositional and tacit knowledge associated with development and use of models that is essential in active learning. This is in contrast to environments for active learning in which the learner either plays the role of a programmer (as in Logo) or of a user (as in interaction a microworld). Unpublished research by Roe (2005) provides more context for this claim by demonstrating the significant practical advantages and methodological implications of introducing dependency maintenance to state-of-the-art tools such as Imagine Logo (Kalas and Braho, 2001).

Modelling with dependency has potential application to collaborative learning. The benefits of spreadsheets as shared computer-based models for distributed and concurrent interaction in collaborative environments are well-recognised (Nardi, 1993). Construals can embody each individual learner's understanding of a situation, and be adapted to underpin novel processes of interaction and evaluation. For instance, in evaluating student performance in a model-building exercise, a teacher can keep a comprehensive record of their interactions with the model, and return this to the student as an auditable source of feedback.

Modelling with dependency can help to combat the acute problems of customisation and interoperability that arise in educational technology. The well-conceived use of dependency in model-building enables a degree of model interconnection and interoperability that is unprecedented in traditional software development. Dependency-based models can also potentially serve as a single source from which programs for specific target platforms and special learner needs can be derived by a process of specialisation and translation (Beynon et al, 1988; Beynon & Cartwright, 1997), as has been demonstrated in ground-breaking new approaches to cross-platform broadcasting for interactive digital television (BBC R&D Cross-platform Interactive Television: http://www.bbc.co.uk/rd/pubs/brochures/ibc2003/bbc-rd-cross-platform-interactive-tv.pdf).

Wider implications

The potential wider implications of our new conception of computing technology can be conveniently reviewed under three different themes identified by Price et al. (2005):

Political change - The insidious influence of machine metaphors for human cognition on the conception of human-centred activities such as commerce and education is one of the most unhappy side-effects of the insight into rule-based systems gained during the twentieth century. A surprising side-light on this development, as remarked by Emil Post (1965/1941), was that formalization in mathematics continued to attract the highest level of prestige and interest despite fundamental results by Gödel and Turing that demonstrated their inherent limitations. Writing in 1941, Post called for a reappraisal of the priorities in mathematical research, stressing "that mathematical thinking is, and must be, essentially creative" and expressing the expectation - and hope - that mathematics would "reverse the entire axiomatic trend of the late nineteenth and early twentieth centuries, with a return to meaning and truth". Contemporary education policies, both in schools and higher education, seem to promote a culture with many characteristics of formal systems, and invite a similar critique. The new conception of computing technology proposed in this paper can be interpreted as lending support to an alternative culture, in which less emphasis is placed upon stereotypes both where the academic curriculum and the evaluation of performance are concerned (cf. Beynon & Russ, 2004).

Technology adoption - This paper argues that the conception of computing technology that underpinned the first attempts to exploit computers in schools, and that has dominated subsequent developments in educational technology (with the notable exception of spreadsheets), is ill-suited to supporting active learning. In particular, it involves modes of software development that make the dynamic and subtle changes to the requirement demanded in educational applications hard even for the professional to implement. The proposal outlined above aims to give teachers the levels of autonomy in developing educational software to which many originally aspired. Specifically, it identifies the need for educational software development to be a do-it-yourself activity that is intimately bound up with domain learning and understanding, and that ideally can be conducted incidentally in conjunction with other teaching preparation - that is, without requiring the extremely high levels of expertise, concentration and commitment currently demanded of the professional developer (Beynon, 2001).

Models of teaching and learning - Educational software is conceived or customised by the teacher; designed, implemented and maintained by the developer; used by the learner. These activities all take place in quite different contexts, and invoke sharply distinct perspectives and interfaces, each deliberately crafted to serve a specialist function. Such a disjunction of teacher, learner and developer activities results inevitably from a conception of computing that is predicated on separating the core formal computation from the rich penumbra of informal but essential interpretative activities that engage with meaning. Computer science and educational technology alike have adapted to this dualistic outlook, but such duality is not respected in practical computing or active learning, where construction and meaning are inextricably linked. To question the status of this duality is not to deny the significance of the classification of pedagogical activities proposed by Shaffer and Kaput (1999), after Merlin Donald (1991), that is further discussed in Riley (2005a). Computing technology will no doubt initiate a new stage in the evolution of human cognition and culture, but it is its dualistic conception that informs the notion of a virtual culture that "has its roots in the need to conduct more and more complex processing of information using formal mathematical systems" (Shaffer & Kaput, 1999). The conception of computing technology proposed in this paper has elsewhere been discussed in conjunction with a classification of learning activities that likewise ranges from what are perceived to be the most primitive to the most sophisticated modes of human interaction and behaviour (cf. the Experiential Framework for Learning (Beynon & Roe, 2006; Beynon, 2006a)). The significant difference is that, in that context, these learning activities are perceived as part of a holistic vision for learning in which modes of interaction at many levels, using a wide variety of supporting human and computing technologies, are typically concurrently invoked. It is such a vision that seems most appropriate if computing technology is to liberate the qualities of "wild imagination, passion, being close to nature, and believing in magic" that Papert has in mind.

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Teaching in a wireless learning environment: A case study

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ABSTRACT

Although wireless and mobile technology is regarded as a useful tool for enhancing student-centered learning, few studies have explored the factors that may affect the application of this emerging technology in classroom situations. Accordingly, this study selects three factors (instructional belief, instructional routine, and features of wireless and mobile technology) via literature review, then utilizes a case-study method with a focus class and teacher to explore the effects of these factors on teaching in wireless environments. The main study results are summarized as follows: first, the case teacher held positive beliefs regarding student-centered instruction and innovative technology, but the teacher's instructional practices were significantly restricted by the teacher-centered approach. This inconsistency between instructional beliefs and practices resulted in the teacher being willing to apply wireless technology but unable to bring it into full play. Second, the strong stress and misgivings about changes in instructional methods prevented the teacher from altering instructional routines. The contrast between student expectations regarding technological applications and the practical application of technology by teachers caused negative reciprocal effects. Finally, the workshop that adopted top-down dissemination and did not use on-site support in this study cannot encourage changes in instruction methods used by teachers. It is recommended that effective learning communities and teacher development programs be developed.

Keywords

Instructional change, Technology and instruction, Wireless & mobile technology, Teacher belief, Innovative educational technology

Introduction

Technology is often considered valuable for increasing educational benefits and instructional quality (Dexter, Anderson, & Becker, 1999). Mobile devices, wireless communications, and network technology have recently advanced significantly, and have been integrated into various wireless learning environments that attract many individuals' attention and expectations (Roschelle & Pea, 2002; Norris & Soloway, 2004). For instance, many studies have predicted that wireless learning environments have the potential to create something new and significantly impact education (Roblyer, 2003; Roschelle, 2003; Penuel, Tatar, & Roschelle, 2004).

Wireless learning environments offer many educational possibilities that are not easily achieved in other learning environments. Mobile devices enable both the teacher and students to employ computing power without time or location constraints, while the Internet and wireless technologies enable mobile devices to interconnect seamlessly with each other or with other computing devices. Wireless learning environments have the following features based on seamlessly linking various computing powers with mobile learning devices at hand, including: (1) enhancing availability and accessibility of information networks; (2) engaging students in learning-related activities in diverse physical locations; (3) supporting group work in projects; (4) improving communication and collaborative learning in the classroom, and (5) supporting quick content delivery (Gay, Stefanone, Grace-Martin, & Hembrooke, 2001; Roschelle & Pea, 2002; Hoppe, Joiner, Milrad, & Sharples, 2003; Liu et al., 2003; Wang, Liu, Chou, Liang, & Chan, 2004; Liang et al., 2005; Zurita, Nussbaum, & Salinas, 2005). Therefore, wireless learning environments are regarded as more suitable than ordinary classrooms or computer classrooms for supporting teaching and learning based on learner-centered teaching methods (Roschelle, 2003; Zurita et al., 2005), described as "active, productive, creative and collaborative learning methods" (p. 255) by Hoppe et al. (2003).

Although previous survey studies demonstrated that wireless learning environments can increase students' application time of IT and improve their learning achievement and attitude (Crawford & Vahey, 2002; Swan, van't Hooft, Kratcoski, & Unger, 2005), some researchers (van't Hooft & Swan, 2004) have pointed out the insufficient number of empirical studies on the educational applications of wireless and mobile technologies. Learning with innovative technologies does not automatically provide the benefits of these technologies. Many factors influence the application of technology in classrooms and determine its educational benefits, such as the pedagogical approach of teachers, technology used, infrastructure and support, training regarding technology application, teacher attitudes about educational technology, teacher classroom practices, classroom management skills, and so on (Greenberg, Raphael, Keller, & Tobias, 1998; Zucker, 2004). Because the factors affecting technology application affect each other, the actual influences and effect processes of these factors are difficult to identify.

Moreover, most researchers and teachers do not understand emerging wireless learning environments as well as they do ordinary classrooms and computer classrooms. The factors affecting teaching and learning in wireless environments and their effects are not yet clear and, therefore, must be intensively explored before strongly promoting teaching in wireless learning environments (Penuel et al., 2004; Zucker, 2004; Zurita & Nussbaum, 2004).

A case study is a particularly appropriate way to explore the possible effects on teaching and learning of wireless and mobile technologies. As an empirical and holistic inquiry, a case study explores a single instance, phenomenon, or social unit within its natural setting (Yin, 1994; Merriam, 1998). Case studies are often adopted to study the problems or effects that a specific case (a class with a teacher) encounters when it applies innovative technologies in a classroom (e.g. Lin, 2001; Seppala & Alamaki, 2003; Young, 2003), and can form the basis for the development of more general, nomothetic theories.

In this study, which is in the first in this series, a case study involving real classroom situations was conducted to explore the possible factors affecting teaching and learning by wireless technology with the following purposes: (1) to identify how these factors affect teaching and learning in wireless learning environments; (2) to understand how these factors affect teaching and learning; (3) to discover how these factors may mutually affect each other, and (4) to recommend directions for the teacher and students in current case study as well as in future studies and training programs that incorporate wireless learning environments into classrooms.

The factors explored in this study

Theories or related research results can be adopted as the starting points to direct or construct the initial set of research questions, and then to explore the case study (Yin, 1994). Some earlier studies found that many interdependent factors influence teaching and learning in wireless learning environments (Zucker, 2004). However, focusing on too many possible factors in one study may make the work too complex to control. Hence, this study initially chose three major factors: the teacher's instructional beliefs, the teacher's instructional routine, and the wireless learning environment. The definitions of these factors, the relevant literature, and the reasons for choosing them are presented below.

Teacher's instructional beliefs

Teachers' instructional beliefs, which reflect their own implicit theories and assumptions about the students, the subjects they teach, the teaching approach, and their teaching responsibilities, are often considered to play an essential role in their classroom practice (Higgins & Moseley, 2001). Some literature has stated that teachers' instructional beliefs directly influence their pedagogical practices and interaction with students (Clark & Yinger, 1987), and also affect students' learning achievements (Thompson, 1984; Ernest, 1989; Lerman, 1989; Fennema & Franke, 1992).

However, various studies disagree about whether teachers' instructional beliefs are consistent with their own instructional practices (Fang, 1996). For example, some studies have indicated that teachers' instructional beliefs are linked to their pedagogical practices (e.g. Johnson, 1992) or their educational applications of information technology (Drenoyianni & Selwood, 1998; Higgins & Moseley, 2001), while others have concluded that teachers' instructional practices do not always conform to their beliefs (Duffy & Anderson, 1984; Thompson, 1992; Raymond, 1997; Wilson & Goldenberg, 1998).

Because the earlier investigations lacked unanimous results, and because wireless learning environments have the potential to support learner-centered activities, the current study tries to further explore the possible relationships between teachers' instructional beliefs (teacher-centered or learner-centered approaches) and their own instructional practice with wireless technology, and the possible reasons for those relationships.

Teacher's instructional routines

Instructional routines based on teachers' previous teaching experiences are efficient and common instructional modes in situations involving repetitive actions and behavior (Yinger, 1979). Some studies have indicated the practical teaching of teachers frequently follows their own instructional routines (e.g. Parker & Gehrke, 1986). Instructional routines, when applied properly, can increase the teachers' effectiveness by freeing their time and energies from decision-making during instruction (Yinger, 1979). However, the features of instructional routines, intuition and automation may also reduce the flexibility and changeability of teacher instructional practices when teachers implement innovative technologies, such as wireless and mobile technologies.

The introduction of innovative technologies into the classroom increases the complexity and unpredictability of instructional and learning situations (Fang, 1996), and often requires teachers to adjust their usual practices of instructional decision according to the novel situations. However, when trying to implement innovated technologies, teachers often resist changing their instruction, reducing the flexibility of their instructional decisions, and preventing the technology implementation from producing the expected educational benefits (Drenoyianni & Selwood, 1998).

Based on the above literature, this work studied how teachers' instructional routines affect their own practical teaching and technology application in the wireless learning environment.

The wireless learning environment

Mobile and wireless technologies have become very promising technologies for supporting learner-centered learning (Hoppe et al., 2003). Their integration can expand technologies as part of the campus environment for teachers and students to adopt and enable students to share information and coordinate their works (Gay et al., 2001).

The educational application of mobile and wireless technology rises rapidly, but empirical studies on learning activities involving these technologies are still rare. Most empirical studies adopted the interview or questionnaire method to evaluate the effectiveness of wireless learning environment. The following conclusions were drawn: **(1) Improving learning achievements.** Some studies have revealed that wireless mobile devices improve student learning across curricular topics and instructional activities (Crawford & Vahey, 2002). Moreover, the application of mobile learning devices has been found to enhance students' learning processes, support students' completing schoolwork, and improve students' conceptual understanding (Swan et al., 2005). **(2) Promoting learning motivations.** Swan et al. (2005) found that mobile computing devices excite students and engage them in learning, especially when they are writing by hand. Teachers have found that students are more motivated and spend more time learning when they use mobile learning devices (Crawford & Vahey, 2002)., than they do in the traditional classroom. Van't Hooft, Diaz, & Swan (2004) performed a survey of 217 students and found that most students liked using mobile devices, thought using mobile devices made learning more fun, and viewed mobile devices as a valuable learning tool.

Although the results of the above study could popularize efforts to teach in wireless learning environments, many details are worth further study. For instance, some empirical studies (van't Hooft et al., 2004) found that most students often adopt mobile devices for activities unrelated to formal learning (such as playing games). Accordingly, some questions emerge regarding whether teachers agree that students use their own mobile learning devices freely and flexibly in classrooms and whether students will still have positive attitudes to learning within wireless learning environments if teachers restrict the way students use their own devices. To explore these questions, this study collects and analyzes data about student learning attitudes.

Central Questions

The following four sets of central questions for the study have been identified from the research literature.

- How are the case teacher's practical instructions (in an ordinary classroom or the wireless learning environment) and his/her own beliefs about instructions and technology applications related? Additionally, why do these relationships occur?

- How and why do the teacher's instructional routines affect his/her own practical teaching and technology application in the wireless learning environment?
- How does the wireless learning environment support the teacher in implementing appropriate instructional practices and technology applications?
- What are the mutual effects among these factors (such as beliefs about instruction and technology application, instructional routine, and wireless instructional environment) during teaching and learning in wireless learning environments? Additionally, how do these effects further influence student attitudes toward learning with wireless technology?

Research Design and Method

To study deeply the effects of various factors on teaching and learning in the wireless environment through detailed and intensive classroom observation in real situations, this study performed a case-study approach, and employed a focus class to collect and analyze data about learning mathematics in wireless learning environments.

Case selection

Before the current study was conducted, several elementary schools had been selected as the key schools of IT, and given financial assistance by the government of Taipei City, Taiwan to set up wireless learning environments. The purposeful selection was employed to select the study case from among the teachers and their classes of these schools, and the major selection criteria are displayed as follows: (1) the school administrators must support the case study, and the case class must permit long-term observation in the classroom to collect data about teaching and learning in real situations; (2) the class in the case study must be in the fifth or sixth because students in these grades can already utilize and implement learning devices; (3) the class teacher must have enough teaching experience to form his or her own instructional routines, and (4) the teacher and students in the class must be unfamiliar with the applications of innovative technologies.

The target teachers were individually interviewed to inform them of the purposes and procedures of this study, and to ascertain their willingness to participate in this study. Finally, a teacher and class that met the selection criteria were chosen for the study. Furthermore, the researchers were invited to report the purposes and procedures of this study to the students' parents. The students' parents then agreed to allow their children to participate in the study.

The school of the selected case teacher and class had a long history, and old buildings and instructional facilities. The principal of this school actively supported this study and expected that the current study could illustrate the problems confronting the case class.

The case teacher, who had more than ten years' teaching experience in this elementary school, had taught the case class for over a year before this study began. The teacher had basic IT skills, such as those require for the editing of digital briefings and word processing, and considered IT useful in education, but seldom applied IT technologies practically in his teaching. Moreover, the teacher was very active and enthusiastic about the teaching profession. His motives for participating in this study were to attempt to apply wireless technologies in education, and to review and improve his own teaching skills.

The selected class was made up of students in the sixth grade, several of whom had no computer in the home. The classroom contained a computer connected to a fixed overhead projector. The case teacher often used this computer to edit instructional materials and assignments, but rarely applied the projector in teaching.

The wireless learning environment applied in current study

The wireless learning environment of the case class was the Wireless Technology Enhanced Classroom (WiTEC), which was financially supported by the Taipei city government. The WiTEC system was developed in 2001 by the Learning Technology Center of National Central University, Taiwan. In the study, WiTEC was suitable as a wireless learning environment for two reasons. First, WiTEC, designed for general learning purposes, has features common to many wireless learning environments, as described in the second paragraph of the introduction. Therefore, the results of this study can be generalized to many wireless learning environments. Second, the earlier studies discovered that the seven modules (see Table 1) of WiTEC can be flexibly and easily applied to support learner-centered activities, such as cooperative/collaborative learning activities (Wang, Liu, Chou, Liang, & Chan, 2004) and project-based learning activities (Liu, et al., 2003). Thus, WiTEC could help the current study in exploring whether the case teacher adapts the coincident instructional approach in the wireless learning environment.

Table 1. Seven modules and related functions of WiTEC

Modules	Major users	Functions
Displaying	Teacher	Illustrating prepared digital materials, and taking notes on the e-whiteboard
Broadcasting	Teacher	Transmitting information shown on the e-whiteboard, such as digital materials and notes, to all students' tablet PCs.
Selective and Spot Inspection	Teacher	Obtaining students' assignments from their tablet PCs, displaying them and taking notes on them via the e-whiteboard
Individual Learning	Students	Reading learning materials, taking personal notes and revising their work via tablet PCs
Online Learning	Students	Searching, accessing, and saving online resources or interacting with communities outside the school via wireless networks
Cooperative Working	Students	Co-editing a group report with other group members
Integrated-response displaying	Teacher & Students	Teacher: Showing a multiple-choice item on the e-whiteboard Students: Sending their answers via learning devices Teacher: Showing the correct answer, students' responses, or frequency chart of students' option on the e-whiteboard

Note: The teacher can use the "lock" and "black screen" options to prevent students from operating their own mobile learning devices during teaching.

Data Sources

Observations of the teaching and learning activities in the case class: Non-participant observation was adopted to collect data about the case teacher's instructional practices and students' learning activities in real situations. The researchers sat at the back of the classroom to avoid interfering with the case teacher's teaching, and recorded the class activities.

Interviews with the case teacher: (1) The teacher was interviewed at the beginning of this study to collect data about his background, and his beliefs on instruction and the application of IT to education. The interviews were semi-structured. The original interview questions are listed in Appendix A. (2) The teacher was interviewed twice each week of the study to discuss how he taught mathematics on that day. The entire interview process was tape-recorded with permission of the teacher.

The case teacher's instructional documents: The following documents were used to complement and explain the records of the classroom observation: (1) ordinary documents, such as teaching materials, assignments, and examination papers, and (2) documents needed by the researcher, such as lesson plans and instructional journals.

The students' learning journals: After each mathematics lesson, all students of the case class were asked to take ten minutes to record their views on either or both the learning activity or their mood. The study assistants then immediately gathered the completed learning journals. The case teacher knew that his students had been asked to write learning journals, but he never saw the journal contents. In order to ensure understanding, further interviews were conducted with the students whose learning journals revealed unclear or incomplete ideas.

Data arrangement and analysis: The personal identifiers of the case teacher and students in different data were removed during the data-coding procedure.

The case teacher's instructional practices (including instructional routines): Triangulation was adopted to analyze instructional practices of the case teacher. The typewritten protocols of classroom observation, teacher's interview notes, observation notes, and instructional documents related to the same instructional activity were compared (with conclusions made) to represent the instructional routines or practices of the case teacher.

In addition, the researcher further clarified and classified the case teacher's instructional routines or practices as either teacher-centered or student-centered, based on six indexes (please see the Table 2).

Table 2. Indexes for classifying the instructional approach

Approaches / Indexes	Teacher-centered ←→	Student-centered
Teacher roles	A transmitter or director	A guide, facilitator, or assistant,
Teaching goals	Delivery of factual knowledge	Construction of knowledge
Instructional methods	Lectures, demonstrations, etc.	Project-based or inquiry-based learning
Learning autonomy	Few opportunities for students to initiate and control their own learning procedures	Many opportunities for students to initiate and control their own learning procedures
Learning methods	Individual work	Peer collaboration/cooperation
Interactions between the teacher and students	IRF (initiation/response/follow-up) structure with short responses	Dialogic patterns to enhance student thinking

These indexes were derived from various literatures (Jonassen & Land, 2000; Roblyer, 2003) to represent the differences between two instructional approaches (teacher-centered and student-centered). These six indexes respectively represent the features of teacher roles, teaching goals, instructional methods, learning autonomy, learning works and classroom interactions for the two instructional approaches. Similar indexes have been used to identify different approaches for integrating educational technology into teaching (Roblyer, 2003) or the features of learning environments supported by technology (Jonassen & Land, 2000).

Dexter, Anderson, and Becker (1999) noted that technology-using teachers range along a continuum of instructional approaches, from teacher-centered to student-centered. The researchers of the current study contrasted the features of case-teacher instructional routines and practices with the indexes listed in Table 2 to determine the features of the instructional approach used by the case teacher.

Case teacher technology applications. According to the video records of the actual teaching by the case teacher in WiTEC, the time that the case teacher utilized each major function module (the detail of each module, please see Table 1) was recorded and calculated.

Student attitudes towards learning with wireless technology. To understand student learning attitudes, the student learning journals were classified according to their contents: "with positive comments," "with negative comments," "with both positive and negative comments," "with no comments," and "non-delivery." Then the frequency distributions of learning journals were calculated for different time periods and compared. Moreover, the qualitative data of learning journals and interview protocols were further analyzed to explore the influences on student learning attitudes.

Duration of the study

The study was divided into three major phases: before the wireless technologies were incorporated in the case class (Phase one); the case class familiarizing itself with wireless technologies and related activities (Phase two), and after the wireless technologies were incorporated in the case class (Phase three).

Phase one (8 weeks). The case teacher was first interviewed to ascertain his beliefs. The learning activities of the case class were then observed and recorded on video (about twice a week, for two periods of 40 minutes each time). The case teacher was interviewed at least once a week to collect data regarding his ideas about his teaching.

Phase two (4 weeks). The case teacher participated in workshops (six workshops, each six hours in length, for a total of 36 hours). By observing the expert teachers' demonstrations and through practical training in the WiTEC, the participants learned (see Appendix B): (1) how to operate the functions, (2) how to implement collaborative-learning activities in the wireless learning environment, and (3) how to design applicable instructional materials. Appendix B shows the phases and main instructional tasks of the collaborative learning activities in the wireless learning environment that the expert teachers demonstrated, and the participants learned by practical training.

Furthermore, the case class students were guided to master the operations of their own mobile learning devices (six two-hour lessons, for a total of 12 hours).

Phase three (8 weeks). This phase aimed to clarify and analyze: (1) the case teacher's instructional practices and applications of technology in the wireless learning environment, and (2) the ideas and comments of both the case teacher and the students regarding learning and teaching with wireless technology. The case teacher's mathematics lessons continued to be observed and recorded twice a week, and the teacher was still interviewed to collect his views on his teaching at least once a week. However, unlike in Phase 1, the key aims of the observation and interview were to collect data not only about the case teacher's instructional practices but also about his application of technology.

Results

Phase one: Before wireless technology was introduced into the classroom

The interview data on the case teacher's beliefs indicate that he thought that the learner-centered approach was better than the teacher-centered approach, and that he expected himself to guide and encourage students' active learning. For instance, the case teacher responded to the researcher's question, "What role do you think the teacher should play during teaching?" by saying that, in the past, teachers were like dominators teaching in their own way in their classroom but now students are the protagonists and teachers should be the guides. Moreover, the case teacher stated that implanting knowledge was emphasized in the past, and now the heuristic or constructivist teaching method is seen as correct. Therefore, the case teacher expected himself to be a competent guide.

The interview results also reveal that the case teacher was willing to teach with wireless technologies, and that he thought that wireless technologies are effective teaching tools that can help students learn actively. For instance, the case teacher answered the question, "What does you think about wireless technologies?" by stating that he was willing to try to apply wireless technology because he thought that it could help his teaching, even though he had seldom applied IT in his class before. He also indicated that giving every student his or her own tablet PC could make learning more enjoyable.

Conversely, the analytical results on the case teacher's instructional practices indicate that the case teacher's teaching tended toward the teacher-centered approach. The instructional procedures used by the case teacher typically included lecturing based on the textbook, the students doing their assignments, and the teacher displaying and checking students' finished work. The case teacher seldom offered students opportunities to express their ideas during these processes, and where he did, he often asked questions with "yes or no" answers or about factual knowledge. For instance,

> *Teacher: What are we learning in this unit, Chen-An (not his real name).*
> *Chen-An (opens his book and reads): The decimal is multiplied by the integer.*
> *Teacher: The decimal is multiplied by the integer. Very good!*
> *Teacher: Come. Come up and cite an example question in the textbook for us to see what kind of problems we are going to solve in this unit.*
> *(Chen-An moves toward the blackboard and writes the example question on the blackboard.)*
> *Teacher: Let's see how to calculate this question.*

(The teacher works out the answer on the blackboard, and lectures on how to solve the question that Chen-An has written on the blackboard.)

Phase three: After the wireless technology was introduced into the case class and workshops were completed

The analytical results concerning the case teacher's instructional practices indicate that the case teacher's teaching method during this phase was very similar to that of Phase one. The case teacher frequently: (1) displayed the teaching materials on the e-whiteboard and lectured, (2) handed out assignments, (3) monitored students doing assignments, (4) displayed and checked students' finished assignments on the e-whiteboard, and (5) showed and lectured the correct way to solve the problem. The teacher generally applied the WiTEC modules to demonstrate and lecture materials, and seldom employed the modules to support class interaction and group work.

The case teacher's typical instruction method in the wireless environment is explained here with the following scenarios for teaching the concept of percentages.

(The teacher blacks the screens of all students' learning devices, and explains the textbook contents displayed on the e-whiteboard.)
Teacher: When the denominator of the fraction is 100, this fraction is called the percentage. [The percentage] can be used to display the part that accounts for the whole. Understand?
(The teacher shows another page on the e-whiteboard.)
Teacher: Consider this question (the teacher points his finger at the frame of the teaching material): there are two equal-sized moon cakes. Hanyu eats five-sixths of one [of the moon cakes] (the teacher writes "5/6" and circles it), and Pinyin eats four-fifths of another [moon cake], (The teacher writes "4/5" and circles it). Who eats more moon cake? All right, how did we calculate this kind of question in the past? We should expand the two fractions to a common denominator and then directly compare the size of the two.....
(The teacher continues to teach in this manner.)

In this case, the case teacher spent most of his teaching time demonstrating how to solve "percentage" problems, and spent little time allowing students to express their ideas and solve these problems by themselves. Moreover, although the case teacher assigned all students into several groups like the expert teacher in the workshop training did, he did not promote group discussion or permit students to make their notes in their tablet PCs. The teacher mostly showed his instructional materials and keys to the exercises on the e-whiteboard.

The analytical results concerning the case teacher's wireless technology applications show that the case teacher tended to use the modules that could support teacher-centered teaching. Table 3 lists the average time and percentage of time taken by the case teacher to teach specific function modules in a lesson. The following sections describe the attributes of the case teacher's technology applications that can be concluded from this table and the typewriting protocols.

Table 3. Case teacher's applications of wireless technology

The modules		Average Time (min)	Percentage
1. Displaying	Blacking MLD greens	20.8	71%
	Without blacking MLD greens	2.7	9%
2.	Broadcasting	0.0	0%
3.	Selective and Spot Inspection	3.8	13%
4.	Individual Learning	2.1	7%
5.	Online Learning	0.0	0%
6.	Cooperative Working	0.0	0%
7.	Integrated-response Displaying	0.0	0%
	Total	29.4	100%

- The case teacher spent on average 29.4 minutes of a 40-minute lesson teaching with the WiTEC modules.

- The case teacher spent the most time applying Module 1 to display, making notes on the e-whiteboard and lecturing (about 80% of the total time). During this process, the case teacher often blacked the screens of all students' learning devices (about 71% of the total time) and asked all students to look at what was displayed on the e-whiteboard.
- The case teacher, in general, offered students very little opportunity during lectures to learn using their own tablet PCs (about 7% of the total time).
- When the students completed the individual assignments on their own learning devices, the case teacher sometimes employed the "Selective and Spot Inspection" module to review a specific student's finished work on the e-whiteboard (about 13% of total time). However, the students were seldom offered the chance to freely express their ideas about their own completed assignments during this process.
- Four modules were not used in the technology-supported instructional activities: the "Broadcasting" module, which can enhance the utility of students' mobile leaning devices, the "Online earning" module, which enables students to access many Internet resources, the "Cooperative Working" module, which can help students work together, and the "Integrated-Response Displaying" module, which immediately displays the responses of the whole class.

Responding to the interview about the impressions and evaluations of teaching with wireless technology, the teacher approved of the "Displaying" modules, and thought that retrieving the instructional materials from the computer and taking notes on them made teaching easy.

The students' comments about learning by wireless technology. The students in the case class delivered their own learning journals a total of ten times. Table 4 presents the average numbers and average percentages of students' learning journals on each status, including the journals with positive comments only, negative comments only, both positive and negative comments, no comments, and non-delivery. The average percentage of students' learning journals with positive comments only (45.1%) was higher than that of students' learning journals with negative comments only (35.9%). These data show that the students tended to respond positively to learning with wireless technology.

Table 4. Average number and percentage of responses in student journals (n =10)

	Positive	Negative	Both	No Response	Non-delivery	Total
Number	12.6	10.0	3.5	1.5	0.4	28
Percentage	45.1%	35.9%	12.6%	5.5%	1.4%	100%

However, the frequency distributions of students' learning journals in each time period reveal that the number of students with positive comments (the sum of the number of students with only positive comments plus the number of students with both positive and negative comments) fell over time (see Figure 1). On 2/16, marking the start of Phase 3, 24 students (86% of the 28 students) made positive comments about their learning in the wireless environment. On 3/30, at the end of this phase, only six students (21% of all students) had positive comments. Conversely, the number of students with negative comments (the sum of the number of students with only negative comments plus the number of students with both positive and negative comments) generally increased over time. On 2/16, only one student (4% of all students) recorded negative comments. On 3/30, 22 students (79% of the total students) made negative comments on learning in the wireless environment.

The learning journals and the interview protocols were further analyzed to explore the possible reasons why students made these comments. The analytical results are as follows. First, most students made many positive comments on their learning with wireless technologies at the start of this phase because they were expectant and curious about learning in the wireless environment. For example, one student wrote that he was very excited and happy because he had not had the experience of using a tablet PC in class before. Another student wrote that she was very nervous and happy because it was her first time using a PC to learn. Moreover, the student wrote that she operated the tablet PC very carefully according to the steps given by the teacher, and that she hoped that she could be as happy in the next mathematics lesson.

However, as the students' experience of learning with wireless technologies increased they gradually came to realize that the real practice was less appealing than their expectations. They also thought that learning with wireless technologies had many negative aspects, such as: (1) the activities were monotonous, (2) students lacked opportunities to operate tablet PCs, (3) students had fewer opportunities to express their own ideas than before, (4) students had fewer opportunities to perform practical mathematics tasks than before, and (5) the teacher became strict. For instance, one student wrote that learning with a tablet PC was no different from learning without one, because they were not allowed to use the tablet PCs freely. Another student declared that the teacher talked too quickly for them to understand what the teacher said. Some students stated that the mathematics lessons became very boring because the students had little time to experiment practically with mathematics and were not permitted to express or discuss the concepts.

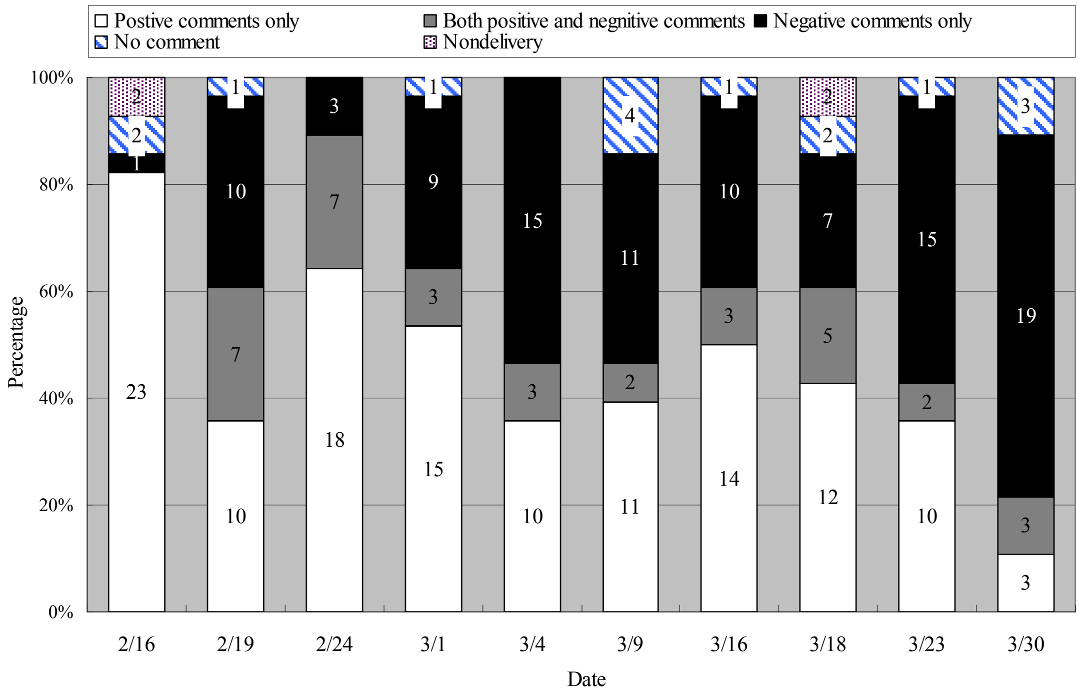

Figure1. Student comments on learning in the wireless learning environment

Moreover, the results of further analysis by comparing students' learning journals and interview protocols with the case teacher's interview protocols, indicate that: (1) the features of the case teacher's instructional activities and technology applications resulted in negative learning attitudes among the students, (2) students' negative learning attitudes further caused negative emotions in the case teacher, and (3) the case teacher's negative emotions further affected his own teaching and his students' attitudes toward learning.

Discussions and recommendations

The following sections discuss and recommend some important issues concerning the research questions and analytical results mentioned in previous sections.

Instructional beliefs

The analysis results show that the case teacher's instructional practices, with or without wireless technologies, were inconsistent with his instructional beliefs. Before the current study started, the case teacher had already expounded the importance and soundness of the learner-centered instructional approach and of IT applications in the classroom, and expected to play the role of guide or promoter to improve students' learning. However, the case teacher's real instructional practices tended to be teacher-centered rather than learner-centered in both the ordinary classroom and when in the wireless environment. The case teacher often lectured, and seldom allowed students to express their ideas, handle experiments, operate the tablet PC, or perform group work.

This case is consistent with some earlier studies that indicated that teachers' instructional practices do not always conform to their beliefs (Thompson, 1992; Raymond, 1997; Wilson & Goldenberg, 1998), especially for teachers whose beliefs correspond to mainstream perspectives and social expectations. The study of Wilson & Goldenberg (1998) indicated that most teachers who participated in educational reforms "generally held reform-based views of mathematical learning and instruction." However, these "reform-minded teachers did not seem guided by their beliefs when making instructional decisions" (p. 227).

Furthermore, some other researchers have proposed reasons why teachers' instructional practices may not be consistent their own instructional beliefs. Fang (1996) noted that the teacher beliefs surveyed by the interview or self-reporting, "… may reflect what should be done rather than what is actually done in class" (p. 53). Teachers could express their own ideas with fervor and assurance outside the classroom, but their real instructional decisions and classroom behavior are often governed by their instructional routines and the classroom contexts (Duffy & Anderson, 1984).

In summary, the teachers with positive attitudes about learner-centered approaches and technology applications may attempt to apply the wireless and mobile technologies in their classroom (just as the case teacher did). However, the teachers who approve of the learner-centered approach but teach in the teacher-centered way may start to confront problems after the wireless and mobile technologies are fully introduced into the classroom. Therefore, teachers' beliefs, especially when surveyed by interview, are not the most appropriate index to predict teachers' actual practices when implementing innovative technology.

Instructional routines

The instructional routines of the case teacher significantly restricted his teaching approach in the wireless learning environments. This study found that the case teacher's instructional practices and decisions were not freed from existing teacher-centered routines, even though the wireless learning environment had the potential to support students' active learning and group working, and even where the case teacher had positive attitudes to learner-centered teaching and IT application.

The case teacher preferred to adopt innovative technologies fit in with his existing instructional routines when employing wireless technology in a real classroom. The case teacher tended to use wireless environment modules that could support teacher-centered teaching, and avoided applying those that required students to actively operate their own tablet PCs. For instance, the case teacher liked to employ the "display" module to support his lectures. Furthermore, even when the teacher used the "Selective and Spot Inspection" module to display the students' finished assignments, he spent most of his time correcting students' assignments, without offering students the chance to express their ideas.

Close attention needs to be paid to the classroom roles and rules, because they mediate the usage of mobile and wireless technologies (Penuel et al., 2004). Earlier literature found that teachers often teach with innovative technologies in their familiar way, but without using these technologies fully or effectively. For example, one of the challenges hindering widespread adoption of handheld-centric classroom is that teachers who use handhelds are not using the student-generated documents as primary assessment instruments, as experts suggest, but are instead using handhelds simply as just a substitute for paper (Norris & Soloway, 2004).

Teachers' instructional routines can affect their teaching approach with innovative technology. Observing teachers' instructional behavior is not only a useful way to study teachers' real-life practices, but is also necessary to understand the teachers' existing instructional routines and to find possible obstructions to introducing novel programs or technology into classrooms.

Wireless learning environment

Wireless and mobile technologies cannot effectively change the case teacher's instructional practices. Wireless technology has many features which benefit the implementation of learner-centered instruction. However, technology cannot "automatically cause" changes in teachers' instructional practices (Dexter et al., 1999, p. 236), and the technology itself cannot help teachers move from a teacher-centered to a student-centered approach (Greenberg et al., 1998).

Introducing wireless learning environments into the classroom placed the case teacher in a dilemma: the case teacher needed to change the instruction to fit the features of the innovative technology, but this change caused stresses. Fully adopting the features of the wireless and mobile technology required the case teacher to make significant changes from familiar instruction, thereby causing significant changes in classroom phenomena, such as types of classroom interaction, social relationships between class members, and the nature of teaching materials and assignments. Such major changes caused unfamiliarity, uncertainty, and complexity to the case teacher, and made him feel stressed.

Moreover, wireless and mobile technologies do not solve general problems in the classroom, and might cause new ones (Penuel et al., 2004). Wireless learning environments are like a double-edged sword. For instance, wireless mobile devices help students to access online resourses and communicate with other people, but may also distract students from the teacher's lecture for this reason (Roschelle, 2003). These potential problems also cause the case teacher to be hesitant.

These strong stresses and misgiving still prevented the case teacher from altering his teaching approach, even when the case teacher was aware that his students disliked his method of teaching with wireless technology. Hence, the case teacher preferred to employ the modules that conformed to his familiar instructional approach, rather than adopt the modules requiring changes in his teaching. For example, when being interviewed about why he often blacked the screens of students' learning devices in Phase three, the case teacher answered: "When I am teaching, I don't like my students to use their own devices…If they use their own devices, I cannot control what they do, since I don't even know whether my students listen to what I am saying…I think if I allow students to use their [tablet] PCs freely, then the situation will be more complex."

The study results indicate that future studies should design some useful functions to help teachers fully benefit from the features of wireless learning environments and avoid stress and concerns when developing wireless learning environments. For instance, classroom management functions that help teachers monitor student activities on learning devices without disturbing students' personal privacy are imperative..

The reciprocal effects

Teacher's instructional routines, wireless technologies, and students' expectations caused negative reciprocal effects among the technology, teaching, and learning. Although earlier evaluations found that the mobile devices have the potential to excite students and positively affect students' learning (Swan, et al., 2005), these results were achieved partly because these teachers allowed the students to utilize their own learning devices (such as taking notes, managing personal information, drawing pictures, and transferring files to other devices) to support personalized or cooperative learning (van't Hooft et al., 2004; Swan, et al., 2005).

The student-centered features of wireless technology, and the case students' expectations of using it, gave most students positive attitudes toward learning in a wireless learning environment when the wireless environment was initially introduced to the case class. However, the case teacher persisted with a teacher-centered instructional approach without providing students with chances to operate their own devices, express their ideas, and implement mathematical experiments, disappointing the students and causing their attitudes toward learning to gradually change from positive to negative. Additionally, the students' negative learning attitudes led to increasingly inappropriate class behavior, such as decreased attention and interest during the teacher's lectures, and a failure to hand in assignments on time. This inappropriate behavior negatively affected the case teacher's teaching mood, and hence his instructional behavior.

The negative reciprocal effects among technology, the case teacher's teaching, and the students' learning occurred through these processes because the case teacher maintained his existing instructional routines, which could not match either the features of wireless technology or the students' eager expectations.

Teacher professional development and support

Although the professional development of teachers is not the primary focus of the study, it must still be considered. The study results indicate that the workshop trainings, used to familiarize participants with wireless technology-based collaborative learning activities through observation and manipulation, cannot effectively support the case teacher in changing his own instructional practices. The results of earlier studies may provide some possible reasons for this study result. First, although the case teacher had many chances to observe the experts' teaching demonstrations, which implemented wireless technology-based collaborative activities, he was given few opportunities to understand the experts' thinking and decisions in these implementation processes. Greenberg et al. (1998) pointed out that such workshops were not enough to prepare teachers, particularly inexperienced users of technology, for teaching with technology. The inexperienced users of technology generally did not transfer what they had learned in the workshop into the classroom.

Furthermore, the workshops in this study adopted the top-down dissemination model based on one-shot workshops, with lists of prescribed practices to be observed and implemented, and no on-site support. Some studies have pointed out that such workshops cannot implant changes or sustain innovation (Hall & Hord, 1987; Kaestle, 1993).

Finally, although the principal and the administrators were all willing to provide support and help to the case class, unfamiliarity with the innovative technology and its applications meant that these help providers could not appreciate the problems that the case class confronted, and thus were unable to help effectively. Teachers who attempt to teach in wireless learning environments in the future should have the support of the entire learning community.

This study recommends that future teacher-development programs should try to guide teachers who use technology with a teacher-centered approach toward a more learner-centered approach. This change should be made gradually, because change is a source of stress that often makes teachers retreat to their familiar instructional practices. Moreover, teachers who agree with the student-centered approach but adopt a teacher-centered teaching style may encounter frustration when they actively attempt to teach in wireless environments. Because of this, the teacher-development program must provide these teachers with effective pedagogical and technological support to reduce the gap between their beliefs and their actual practices. Furthermore, teachers are themselves learners when innovative technology is introduced to classrooms. Earlier empirical study results (Liu, 2005) have revealed that effectively integrating technology and learning models (such as the cognitive apprenticeship model) can enhance teachers' professional development. Finally, teachers using teacher-centered instructional routines require adequate on-site guidance to help them to plan, teach, and reflect upon their teaching in wireless learning environments. For instance, after the current study ended, the researcher discussed classroom observations with the case teacher. The researcher also provided the framework for the expert teacher's decision processes within the wireless learning environment in order to guide the case teacher to plan, teach, and reflect upon his teaching with wireless and mobile technologies. The initial results revealed that this guidance and assistance was effective in changing the case teacher's instructional practices, promoting the students' positive learning attitudes, and benefiting the case teacher and students in the wireless learning environment (Liu, preparing). The case teacher has now become his school's seed teacher for promoting the educational application of wireless and mobile technology.

Limitations of this study

Although using a case with a single class and teacher enabled this study to explore some significant issues in depth and over the long term, it also affected the generalization of the results. Further studies with various case classes (or case teachers) and with different methods, such as a field experiment, are recommended.

Furthermore, this case study has identified some issues that require further study, such as the impact of teachers' use of wireless technologies to influence student learning, possible support of teachers' organized learning communities, and the influence of the type of training and support for teachers teaching with wireless technologies. Clarifying such issues can improve the understanding of how to help teachers effectively integrate wireless technologies into their teaching.

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Appendix A: The interview questions with the case teacher

Teacher's beliefs about instruction

1. Please illustrate your perspectives about teaching.
2. Please illustrate your perspectives about the role that teachers should play during teaching.
3. Please illustrate your perspectives about the role that students should play during learning.
4. Please illustrate your perspectives about the teacher-student interaction.
5. Please illustrate your perspectives about classroom management.
6. Please illustrate your perspectives about the relationship between the teacher and students.

Teacher's belief about educational application of technology

1. Please illustrate your perspectives about wireless and mobile technology.
2. Please illustrate your perspectives about integrating technology into teaching.
3. Please illustrate your perspectives about the role that technology should play during teaching.
4. Please illustrate your perspectives about the relationship between technology and teacher-student interaction.

Appendix B: Phases and tasks of WiTEC-based collaborative learning activities

Phase	Principal instructional tasks
Improving students' preparation	1. Adopting the e-whiteboard to show and explain materials to students. 2. Adopting the "Integrated-response Displaying" module to monitor students' understanding of the teacher's illustration.
Monitoring and supporting group work	Guiding students to implement activities, including: 1. Adopting their own tablet PCs to read and note the learning materials and to explore and access more learning resources on the Internet. 2. Sharing and discussing information with other group members. 3. Progressively building a common view of their group tasks, through the reciprocal process of exploring, collecting, sharing, and discussing. 4. Adopting the "Cooperative Working" module to recording, arranging, integrating and revising the group's report.
Guiding groups' presentations and implementing evaluations	1. Guiding each group to demonstrate its own finished report on the e-whiteboard and discuss with the whole class; 2. Noting and checking each group's report, and broadcasting it to each student's learning device); 3. Adopting the "Integrated-response Displaying" module to implement the formal assessment or peer-evaluation and understand students' learning statuses and opinions.

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Deriving Process-driven Collaborative Editing Pattern from Collaborative Learning Flow Patterns

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ABSTRACT

Collaborative Learning Flow Patterns (CLFPs) have recently emerged as a new method to formulate best practices in structuring the flow of activities within various collaborative learning scenarios. The term "learning flow" is used to describe coordination and sequencing of learning tasks.

This paper adopts the existing concept of CLFP and argues that many of these patterns are already using, or could use, collaborative editing activities that need to be process-driven. Consequently, the paper proposes a Process-Driven Collaborative Editing Pattern (PDCEP). The paper also describes how this new pattern relates to the existing examples of CLFPs and IMS-LD best-practices. The proposed pattern incorporates temporal and deontic constraints, used to specify the process of collaborative editing. The approach is demonstrated by an example of the electronic debate learning activity and its corresponding CLFP.

Keywords

Learning Designs, Collaborative Learning Flow Patterns, Coordination, Collaborative editing

Introduction

These days, numerous applications of the existing educational technologies are based on the same content-driven pedagogy. The same approach is also supported by the current educational standards. For example, SCORM (Sharable Content Object Reference Model) by (ADL, 2004) enables sequencing and dynamic presentation of the learning content to a learner, based on their progress through the prescribed material. Furthermore, although the concept of Learning Objects, as proposed by the Learning Object Metadata Standard (LOM, 2002), has evolved to include much more than educational content, it is still widely used to enable sharing of content-based educational resources among different repositories and educational platforms.

However, this content-oriented approach to learning and teaching does not really reflect the reality of creative teaching/learning processes. As (Koper and Olivier, 2004) pointed out, the content-driven pedagogy is based on the following, quite limited, set of guiding principles "Learning is the process of consumption of content… In order to learn, a single user needs to go through a sequence of learning objects… Teaching is the art of: (i) selecting and offering content in a structured, sequenced way and (2) tracking the learner's process and assessing the acquired knowledge" (Koper and Olivier, 2004, pg. 97).

In reality, teaching/learning processes are highly creative and involve collaborative interactions among many roles, guided by various pedagogical models. These processes need to be captured, shared and adequately supported by educational technology. This particular problem has been the main focus of the recently proposed theory of Learning Designs (Koper, 2005). This theory strongly promotes the top-down, rather than bottom-up design of learning experiences. More precisely, it starts from the proven pedagogical models rather than the available technology. This is why this emergent theory appears to be very significant for the future developments in the area of educational technologies (Britain, 2004).

Conceptually, learning designs describe "under which conditions, which activities have to be performed by learners and their teachers to enable learners to attain desired learning objectives" (Koper and Olivier, 2004). The associated

IMS-Learning Design standard (IMS-LD, 2003) promotes formal specifications of learning designs, executable by computers. In this paper, they are referred to as IMS-LD. Ultimately, IMS-LDs can be reused and shared by software platforms as well as teachers. The current version of IMS-LD formal model consists of three components: (i) an information model, (ii) a best-practice and implementation guide and (iii) an XML binding. For more details see (LD-IMS, 2003).

One of the ongoing research and practical challenges in this area is the problem of possible reuse of learning design methods (or their parts). A *learning design method* describes the actual *teaching-learning process* i.e. activities undertaken by all participants (teachers and learners) in the given learning environment (Koper, 2005). Learning design methods are typically derived from the existing educational theories, the examples of best practices used by experienced educators or from common patterns that can be observed in the best educational practices (Koper and Tattersall, 2005). In general, patterns are used to capture common solutions to recurrent problems in a particular domain (Alexander et. al. 1977). In this context, these are common solutions or pedagogical practices used in education. From the knowledge management perspective, it is possible to observe that educational patterns are used to express the experiential knowledge of teachers, related to common teaching/learning practices.

This paper focuses on a special category of patterns called Collaborative Learning Flow Patterns (CLFPs) that have been previously introduced by (Hernandez-Leo et al., 2005). These patterns focus on *learning flows* i.e. coordination and sequencing of learning tasks in a process. More precisely, "CLFPs formulate the best practices in structuring the flow of type of learning activities (and to some extent types of tools) involved in collaborative learning scenarios" (Hernandez-Leo et. al, 2005, pp.76). These patterns are identified by the process called deductive pattern mining, designed to capture the essence of generic models for solutions to recurrent problems identified by experienced learning designers (Baggetun, et. al. 2004). However, the main emphasis of CLFP is on the *learning flows* rather than other aspects of collaborative learning activities (such as, for example, instructional design). There are many examples of CLFPs that can be found in the field of collaborative learning such as Think-Pair-Share, Jigsaw, Pyramid and Brainstorm, as described by (Hernandez-Leo et. al, 2006).

Compared to the existing theory and practice of CLFP, this paper goes one step further. It recognises the fact that during collaborative learning students are often required to collaboratively edit/produce an artifact (i.e. a shared text document/ a piece of programming code /a presentation). In this paper, we use a generic term "document" to refer to all text-based shared artifacts. Collaborative editing is not a new concept. However, in many cases, collaborative editing needs to be *process-driven* i.e. all participants are required to perform certain editing actions at different times and these actions need to be coordinated. Consequently, components of a shared document need to be made available to the right person at the right point of time and these people should be given the appropriate editing rights. Furthermore, certain actions (e.g. editing events) may also generate further obligations for the other participants to perform some future actions within the same process. For example, when a teacher posts a debate issue, two teams of students will be obliged to post their arguments by the given deadline. In essence, many CLFP require (or may benefit from) collaborative editing activities driven by a process.

To capture and describe this process, this paper proposes Process-Driven Collaborative Editing Pattern (PDCEP). More precisely, the paper uses a high-level formal modeling language to express this pattern and capture its temporal and deontic constraints. Here, temporal constraints are used to express temporal relationships among various editing events while deontic constraints are used to capture dynamic obligations, permissions and prohibitions resulting from these events. Formal modeling of these constraints enables formal verification and reasoning about various editing events at the conceptual level.

The paper uses an example of Electronic debate CLFP to motivate the need for the proposed PDCEP. After formally describing this pattern, the paper will also discuss how selection of different types of documents and editing events can lead to different types of CLFP. The paper will also discuss how the proposed pattern relates to the examples of IMS-LD best practices, as described by (IMD-LD, 2003).

Motivating example

Suppose that a teacher is interested to implement an online debate to supplement her/his weekly lecture on computer ethics. From the existing education literature (Habeshaw et. al., 1987; Ramsden, 1992; Angelo and Cross, 1993;

Snider and Schnurer, 2002) s/he knows that the debate learning activity teaches persuasion, argument construction and improves students' critical thinking and communication skills. This well-known activity has been used in many different disciplines to help students gain a better understanding of a controversial issue and explore different perspectives of the same problem.

For the purposes of this exercise, the teacher decides to divide all students into several groups. Ideally each group should have an even number of members, although it is possible to use some other group formation strategy. Each group of students is given an issue to debate. Then each group (e.g. A) is divided into two teams, one that will argue the affirmative side (+) (here called TeamA+) and the other that will argue the negative side of the debate (-) (here called TeamA-). The teacher decides to post a debate issue online, as a follow up to his/her face-to-face lecture. For example, suppose that Group A is given the following issue to debate: "Keeping the electronic versions of private medical records is good for the society". TeamA+ and TeamA- are then given 4 days to prepare their respective arguments and post them online. After both teams have posted their arguments, they are then given 2 days to prepare and post their rebuttals in order to respond to the opposite team's argument. After both teams complete their rebuttals, the teacher will evaluate the quality of their arguments, provide online feedback and select the winning team. Obviously the same scenario is replicated for the other groups (B, C, D etc.)

This activity could be done as a part of student's formative assessment to make sure students understand a critical issue covered by the previous lecture and use the relevant resources to support their argument. Alternatively, it could be used as a part of their summative assessment.

CLFP of Electronic Debate

First of all, it is important to note that the electronic debate learning design method could be analysed from many different perspectives including, for example, instructional design, group dynamics etc. While acknowledging that all these perspectives are important for the given collaborative activity to succeed, this paper focuses on a single perspective, captured by the concept of learning flows. This particular perspective deals with the problem of coordination of individual tasks in the given learning/teaching process.

As a starting point we adopt the existing concept of the Collaborative Learning Flow Patterns, described by (Hernandez-Leo, et. al., 2005). In essence, CLFP represent patterns derived from the common learning design methods used in collaborative learning, that place a special emphasis on the learning flows among all participants in the same process. Therefore, other aspects of instructional design of collaborative learning, although very important, are out of the scope of these patterns. Table 1 describes the CLFP that corresponds to the previous motivating example. To express this CLFP, we use the formal notation also introduced by (Hernandez-Leo, et. al., 2005).

Table 1: Electronic debate described as CLFP, based on the model proposed by (Hernandez-Leo, et. al., 2005)

Facet	Explanation	Collaborative Learning Flow Pattern
Name	Name of the CLFP	Electronic Debate
Problem	Learning problem to be solved by CLFP	A complex, controversial issue that includes two opposing sides of the same argument. Participants are required to defend a position (i.e. argue for or against the debate issue).
Example	A real-world learning activity capable of being structured according to CLFP	Students debating a controversial computer ethics issue such as: "Keeping the electronic versions of private medical records is good for the society".
Context	Environment type in which the CLFP could be applied	Participants exploring two opposing sides of the same controversial issue.
Solution	Description of the proposal by the CLFP for solving the problem	Two debate teams are required to defend their given (chosen) position on the same debate issue. Each team studies the debate issue and collaboratively proposes their argument. When both teams complete their arguments, they are expected to respond to the opposing team's argument. After both teams complete their rebuttals, the teacher evaluates contributions of both teams and selects the winner.

Actors	Actors involved in the collaborative activity described by the CLFP	➢ Teacher ➢ Learners	
Types of Tasks	Types of tasks, together with their sequence, performed by actors involved in the activity.	Teacher: 1. Definition of a debate issue 2. Provision of additional information 3. Group/team selection and dimensioning (optional) 4. Decision about time for each step (i.e. definition of temporal constraints) 5. Progress Monitoring 6. Result evaluation and selection of a winning team	Learners: 1. Access to the debate issue 2. [REPEAT for each group] 3. Selection of two teams (i.e. *for* or *against* debate issue) 4. Team discussion 5. Proposal of team's argument 6. Review of the argument of the opposite team 7. Post team rebuttal 8. Review teacher's summary and the outcome (Until the wining team is selected for each group)
Types and Structure of Information	Description of the types of information identified in the collaborative activity and how they are related.	➢ Input information about the debate issue ➢ Collaborative arguments of both teams ➢ Rebuttals of both teams ➢ Result information including the evaluation of both sides of argument and the selected winning team	
Types and Structure of Groups	Description of the types of groups of learners identified and how they are related.	A number of groups (at least one), each divided into two teams.	

In order to explain how the proposed PDCEP has been identified, it is necessary to start from several important observations related to the above CLFP.

First of all, all roles are engaged in structured collaborative writing. Coordination of their individual and collaborative activities is guided by the corresponding learning flow model, as expressed by CLFP. The coordination aspect is critical for the implementation of this CLFP, because unless the individual activities are done in the right order and at the right time, the resulting process will not make any sense. For example, unless the teacher posts the initial debate issue, students cannot start preparing their arguments. Similarly, in order to prepare their rebuttal, each team should be able to see the argument posted by the other team.

Furthermore, there are also various temporal constraints that need to be implemented and monitored to make sure the activities are synchronised in the right way. These constraints are defined by the teacher to make sure that the overall activity can be completed as required, but at the same time, students are given enough time to complete each task. For example, students are given 4 days to complete the initial argument and 2 days for the rebuttal. Furthermore, when this particular activity is instantiated, students need to have access to various learning resources that are appropriate for this activity, at the right point of time (e.g. current version of lecture notes, relevant internet resources etc.).

It is also important to observe that all identified activities use the same document. Different teams will work on different components at different times. In essence this is an example of collaborative editing of a shared document that is guided by a process described by the corresponding CLFP. Therefore, different roles should have rights to edit different components as required, and these editing activities need to be coordinated. Consequently, all access rights need to be dynamically assigned and revoked. For example, once the initial arguments are completed, members of both A+ and A- teams cannot go back and edit their initial postings. It is also important to observe that access rights are given to roles for different components of the same document (rather than the whole document) for a particular period of time.

The proposed Electronic Debate CLFP is not the only example where process-driven collaborative editing could be, or is, currently used. For example, Brainstorming CLFP (Hernandez-Leo, et. al., 2005) could be also enhanced by process-driven collaborative editing. Thus, to make sure that *all* students contribute, a process could be implemented that require students to post their ideas in the round robin fashion. Again, all editing events need to be coordinated and all editing rights should be dynamically managed to prevent re-editing of the previous postings.

Furthermore, Pyramid CLPF (as described by Hernandez-Leo, et. al., 2005) could also use process-driven collaborative editing because the editing events need to be coordinated and contributions of different groups combined in a certain order. Similarly, the examples of IMS-LD best practices, such as Literature Circles (IMS-LD, 2003) could also incorporate process-driven collaborative editing in a similar fashion. This idea will be further explained in the discussion section of this paper.

In essence, all these examples illustrate that it is possible to observe a common pattern of collaborative editing that is process-driven. This important observation has led us to propose the *Process-Driven Collaborative Editing Pattern (PDCEP)* as described in the next section.

A Formal model of Process-Driven Collaborative Editing Pattern

Let $\mathcal{D}$ be a shared document that consists of a set of components:

$$\mathcal{D} = \{C1, C2, \ldots, Cn\}$$

where all components *C1, C2, ..Cn* are mutually exclusive (i.e. they do not overlap).

A set of roles participating in the collaborative editing process is represented by:

$$\mathcal{R} = \{R1, R2, \ldots, Rn\}$$

Note that, the same role can be shared by more than one person.

A set of editing activities that roles can perform on a given component is represented by

$$\mathcal{A} = \{A1, A2, \ldots, An\}.$$

Process-driven collaborative editing can be represented as a coordinated sequence of editing events *E1, E2, ... En* where each event *Ei* is represented by a tuple:

$$\mathbf{Ei}\ (Rj, Ci, Ak, te)$$

where $Ri \in \mathcal{R}$; $Cj \in \mathcal{D}$; $Ak \in \mathcal{A}$ and *te* denotes the actual (absolute) time of *Ei* completion. This time can be used to determine the order of individual events. At the same time, these events correspond to different tasks as described by CLFP (i.e. *te* corresponds to their start or completion time).

Obviously, some actions (e.g. the teacher posts a debate issue) will result in the subsequent obligations for students to complete their respective arguments by the given deadline. On the other hand, other actions are more informative by nature and do not result in any subsequent obligations (e.g. a teacher posts an additional explanation for the given debate issue). To distinguish between these two types of actions, we adopt the classification proposed by (Searle, 1969) in the context of Speech act theory. This particular theory was developed for the purposes of formal modeling of various speech acts (actions) uttered by people participating in formal conversations. This theory argues that some speech acts (e.g. declarations) have the power to create further obligations for the participants in a particular type of formal conversation (e.g. business negotiation). To distinguish between these and other types of actions, Searle (1969) proposed the concept of *perfomative* and *informative* acts, where the former results in creation of obligations (e.g. an auction bid).

In the context of collaborative learning, we also observe that certain actions (editing events) will result in further obligations, while others are more informative. Therefore, we adopt the same theory and distinguish between *performative* and *informative* actions of different participants and their corresponding editing events.

In the context of collaborative editing this distinction is very important for two reasons. First of all, it is necessary to capture the resulting obligations of different participants so they can be monitored. Furthermore, these obligations create the need for management of dynamic access rights to different components of a shared document that will change according to the temporal constraints defined for the particular CLFP.

To express obligatory actions and dynamic access rights (including permissions and prohibitions), we use the concept of *deontic* constraints. They originate from the so-called deonic logic, introduced by von Wright (1968). This formal logic enables representation of permissions, prohibitions and obligations as well as their relationships (i.e. if an action is obligatory, it has to be permitted). Since its introduction, this formal logic has been used for modeling of organisational knowledge in different domains (e.g. electronic contracting and electronic negotiation systems).

In this context, we use deontic logic to express different obligations, permissions and prohibitions generated by different performative actions (editing events).

Thus, obligations are formally represented by a tuple

Obligation *(Ri, Cj, Ak, tb, te)*

where Ri $\in \mathcal{R}$; Cj $\in \mathcal{D}$; Ak $\in \mathcal{A}$ and (tb,te) is a time interval that denotes period of validity of this obligation. Both times tb and te will be dynamically instantiated during the actual learning activity.

This obligation is used to represent the fact that Ri is obliged to perform action Ak on document component Cj during the given time interval (tb,te).

To fulfill this obligation, role Ri has to have the appropriate access right. Thus, this obligation will automatically generate the following access rights:

Permission *(Ri, Cj, access-type, tb,te)*

where *access-type = {read, write}*

For example:

Permission *(teacher, C1, write, tb, te)*

indicates that the teacher has a permission to edit component C1 during the time period indicated by tb and te. Note that the time interval (tb,te) can be open on the right side to indicate that a particular role has access rights starting from tb until further notice.

Dynamic access rights to different document components will make these components visible to the appropriate roles at the right point of time.

Electronic debate CLFP and the process-driven collaborative editing pattern

Let us now use this formal model to express PDCEP used by Electronic debate CLFP. Due to the limited space, we will represent only a part of this model, that is sufficient enough to illustrate the proposed concept.

First of all, it is possible to identify a set of different document components that are used by different participants at different points of time. Figure 3 depicts the identified components along with their corresponding semantic meaning. Note that their relative position is arbitrary and used only to illustrate the concept.

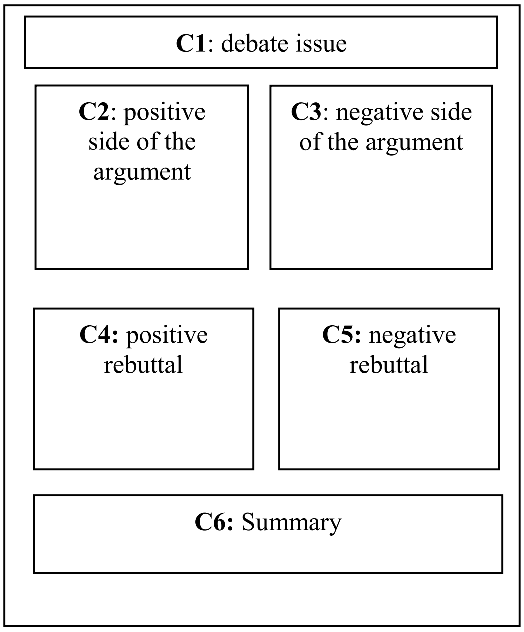

Figure 3: Components of a shared document

Furthermore, there are three different types of roles:

$\mathcal{R}$ *= {teacher, team+, team-}*

note again that the same role may be played by more than one person.

Collaborative editing activities are represented by the following set:

$\mathcal{A}$ *= {"post-debate-issue", "post-argument", "post-rebuttal", "post-summary"}*

The very first collaborative event occurs when the teacher posts a debate issue:

E1*(teacher, C1, "post-debate-issue", t1)*

obviously the pre-requisite for this activity is that teacher has editing rights i.e.

Permission *(teacher, C1, write, t3, t4) where t4=t1*

This temporal constraint "*t4=t1*" is used to express the fact that once the teacher posts a debate issue, this posting cannot be changed. This is because the corresponding permission will be revoked at time *t4*.

Obviously this could be specified in a different way to allow teachers to change their original posting, but any change has to be implemented before students start working on their arguments.

The previous action "*post-debate-issue*" is a perfomative action that will generate the following obligations and permissions:

Obligation *(team+, C2, post-argument, tb, te)*

Obligation *(team-, C3, post-argument, tb, te)*

where in both cases *tb=t1* and *te = t1 + 4 days*

Recall that this temporal constraint "*te = t1 + 4 days*" was originally set up by the teacher, as described by the motivating example. It is used to set the deadline for the submission of the initial arguments by each team.

These obligations will generate automatic permissions for the members of *team+* and *team-* to post their respective arguments (components of the shared document).

However, the following explicit prohibitions have to be added to make sure the opposite teams do not see each other's postings.

***Prohibition** (team+, read, C3, tb, -)*

***Prohibition** (team-, read, C2, tb, -)*

where *tb = t1* and "-" is used to indicate an open time interval.

Suppose that events *E2* and *E3* correspond to *team+* and *team-* posting their arguments, at times *t5* and *t6* (respectively). Suppose that *t6* occurs after *t5* (i.e. *t5* < *t6*).

Obviously, both *t5* and *t6* need to occur within the time interval determined by *t1* and *t4* i.e. both arguments need to be posted on time.

Before each team can prepare and post their rebuttals, they should be able to see the argument posted by the opposite team.

***Permission** (team+, C3, read, tb, -)*

***Permission** (team-, C2, read, tb, -)*

where *tb= t1 + 4* days.

The open time interval *(tb,-)* indicates that both teams will be able to see all postings after the deadline, in this case *tb*.

Alternatively, *tb = t6* means that after both teams post their arguments, they will be able to see the posting of the other team, even before the deadline. It is also possible to set up *tb* so one team can see the argument of the other team as soon as it is posted. This will be all determined by the teacher during the instructional design of this learning activity.

Finally, suppose that *E4* and *E*5 indicate that both teams posted their rebuttals at times *t7* and *t8*

***E4** (team+, C4, "post-rebuttal, t7)*

***E5** (team-, C5, "post-rebuttal", t8)*

again, *t7* and *t8* need to occur before the given deadline of 2 days.

Once they have completed their rebuttals, the access rights of both *team+* and *team-* with respect to components *C2, C3, C4* and *C5,* are revoked back to *"read"* and an obligation is created for the teacher to post a summary.

This activity could be also extended to enable knowledge sharing among different groups. For example, different groups could be given different issues to debate. Then after the teacher posts the summary for each group, all groups could be given the reciprocal rights to read documents posted by other groups.

Discussion

The main objective of this section is to position the proposed PDCEP within the context of the related work. This includes Collaborative Learning Flow Patterns (CLFPs), formal specifications of learning designs proposed by (IMS, 2003) and learning design best practices, as described by (IMS-LD, 2003). This section will also illustrate how the proposed pattern can be reused to create new examples of CLFPs.

First of all, it is important to point out that not every instance of collaborative editing activity is *process-driven*. A group of students can collaboratively write a document and their teacher could be only interested in the final outcome (e.g. the final document). The term *process-driven* means that editing events need to be coordinated but also constrained by the corresponding temporal and deontic constraints. In other words, events are constrained to appear in a certain order and each event may generate new obligations, prohibitions and permissions for other participants in the collaborative process. These constraints are determined by the corresponding CLFP.

Therefore, compared to the existing CLFP, the proposed pattern is conceptually located at a different level of abstraction. At the same time, different CLFP are likely to use, or could use, this pattern. For example, as already pointed out, Pyramid and Brainstorming CLFP as described by (Hernandez-Leo, et. al., 2005), could also implement a process to guide collaborative editing activities.

Furthermore, (Hernandez-Leo, et. al., 2005) describe the relationship between CLFPs and IMS-LD. They argue that collaborative services, currently supported by IMS-LD, are quite limited, as they include only email and discussion forum services. Consequently, they propose an extension to the IMS-LD specification of learning services to include a special type of service, called *groupservices*. In that respect, PDCEP is a further extension of the proposed specification of *groupservices,* at the conceptual level. More precisely, PDCEP describes the process of collaborative editing that is *independent* from any technical implementation. This new pattern includes temporal and deontic constraints (obligations, permissions and prohibitions), that are not captured by the current IMS-LD model of services. Consequently, it is possible to say that the proposed process-driven collaborative editing pattern is conceptually located "between" CLFP and learning services.

The need to formally express the collaborative editing process at the conceptual level, including different events and the associated temporal and deontic constraints, has prompted us to propose a formal model. Because this formal model has its foundation in formal logic, it is possible to use it to reason about different constraints (e.g. to answer questions such as "Is it possible to complete the whole process by the given deadline?"). It is also possible to verify their mutual consistency (e.g. obligations to do certain actions require corresponding permissions). This can be all done at the conceptual level, before the actual learning activity takes place. Reasoning and verification features can be also used to further enhance monitoring of process execution.

At the same time, it is important to point out that teachers are not expected to directly use the proposed formal model. The main reason for going to that level of details was to help us identify and formally express the main components of this pattern (i.e. performative and informative actions, obligations, permissions, prohibitions and temporal constraints). This, in turn, can be used to elicit the requirements for the implementation of an executable, configurable component that will support the proposed pattern. The main idea here is to provide teachers with a template of this pattern (process) so they can configure the individual elements (i.e. change the parameters of the process and the underlying document) in order to implement different CLFP without any programming involved. Ultimately, this component could be offered as a configurable learning service that could be reused by different CLFPs.

The proposed pattern could be also used to help teachers to invent new types of CLFP. This could be done by replacing a given document by other types of documents and changing semantic meaning of various editing events. For example, teachers can implement collaborative editing of their lecture notes. Thus, after a lecture, teacher can post lecture notes and give students several days to add any questions/comments to a particular slide. In the next step, the teacher will go over each slide, identify problematic issues and post a brief answer, give references to further reading or set up some additional activities for students to complete before the next class. Furthermore, the same pattern could be used to implement collaborative reflective journal writing by a group of students, problem-solving exercises, peer-assessment, various forms of electronic brainstorming (such as pooling, nominal group technique), collaborative writing of software applications etc.

Furthermore, PDCEP can be used to further enhance the existing examples of IMS-LD best practices, as described by (IMS-LD, 2003). For example, Literature Circle LD requires students to collaborate and their collaboration need to be process-driven. So when the "Discussion Director" posts a list of questions, this will create obligations for the other roles within the same Circle to contribute within the given timeframe. However, it is also very important to make sure that the overall process is not too restricted by the given constraints. Thus, as students progress through each Literature Circle, their teacher should have the ability to gradually remove the imposed constraints (if required).

In summary, we argue that any collaborative editing activity, where it is necessary to track individual editing events as well as monitor and manage the corresponding temporal and deontic constraints could benefit from the proposed pattern. Finally, it is important to point out that the same concept of temporal and deontic constraints could be further gerneralised and applied to other tasks in CLFP. However, in this paper we concentrate only on the collaborative editing activities. The following section discusses the main challenges related to possible implementation of PDCEP.

Implementation issues

It is possible to support the above described electronic debate activity, or any other collaborative editing activity, in many different ways. Obviously, e-mail or simple sharing of documents (for example in a word format) would make this activity very complex from the administrative point of view. The teacher would need to manually coordinate students' activities, and in some cases, even manually match the original arguments with their corresponding rebuttals for each team and each group. This could be a very complex and time consuming task, as all groups and teams are likely to use different documents.

Another possible option is to use the existing collaborative editing systems. These systems are used to support a group of people to collaboratively edit a document in the synchronous or asynchronous mode. Possible document types include text, diagrams, images, CAD drawings, multimedia, etc.

There are several notable examples of this category of systems. The first category includes Wikiwikiwebs or wikis. This is a family of very popular collaborative editors (http://www.wiki.org). In essence, these are web applications that allow users to freely create and edit a Web page content using any Web browser. In wikis application, there is a central wiki server and a wiki page is duplicated during an editing session without a locking mechanism. In the case of concurrent editing of the same document, the last saved document will be preserved. Modifications are not propagated. In wikis each "save" action, generates a new version of the document.

Real-time editors allow same time/ any place editing of the same document by multiple users. However, one of the major problems, that needs to be solved when building these systems, is the problem of concurrency control. Relevant examples of the previous work in this area are given by (Sun and Chen, 2002).

Currently, the area of collaborative editing mainly focuses on technical issues such as: concurrent editing, data replication and modifications propagation. However, none of these issues addresses the problem of structured collaborative editing as required by PDCEP, proposed in this paper.

In summary, a simple collaborative editing tool is not sufficient. It has to incorporate process-driven support that will guide the editing activities as well as support management of dynamic access rights, as required by the corresponding CLFP. Possible support for PDCEP could lead to more sophisticated learning services. These services could be then used to enable a new type of collaborative learning experience, well-beyond currently available forums and shared documents.

To address this design problem, we are currently considering possible extension of an existing collaborative platform called LibreSource (http://www.libresource.org). This platform was originally implemented to support collaborative development of open source software. Currently, this platform provides all services necessary for collaborative work. From the technical perspective, LibreSource is based on JAVA/J2EE technology. It includes an innovative data sharing management mechanism based on an optimistic data replication and synchronization tool, described by (Molli et. al, 2003). Compared to the existing tools in the same category (such as G-Forge http://gforge.org/ and Savannah http://savannah.gnu.org/), LibreSource offers a high level of integration. In addition to coordination, communication and forum tools, it also provides the awareness and collaborative editing tools. Our aim is to implement the process-driven collaborative editing pattern, described in this paper, by using a flexible coordination mechanism for the collaborative editing process. Implementation of a prototype of this technology is currently in progress by the LORIA ECOO team.

Conclusion

The emerging theory of Learning Designs sees learning/teaching activities as creative, collaborative activities where students and teachers play different roles and their activities are carefully coordinated to achieve the intended learning objectives. One of current research challenges in this area is certainly the problem of sharing and reuse of learning design methods.

This paper adopts the concept of Collaborative Learning Flow Patterns, proposed by (Hernandez-Leo, et. al., 2005). In essence, CLFPs focus on the learning flow perspective of the learning design methods. This paper argues that many CLFPs already include, or could include, collaborative editing of a shared artifact that needs to be process-driven. This means that individual editing events need to be coordinated. Furthermore, it is also necessary to dynamically manage access rights to different components of a shared artifact, to ensure that corresponding obligations can be fulfilled as required.

The main objective of this paper is to propose the so-called process-driven collaborative editing pattern (PDCEP). The formal model of this pattern includes temporal and deontic constraints, determined by the corresponding CLFP. The paper also positions the proposed pattern within the context of the related work including the existing CLFPs and relevant examples of IMS-LD best practices. The proposed approach is illustrated by an example of Electronic debate CLFP.

Our current work includes technical implementation of a prototype of the proposed pattern, based on the ideas presented in this paper. Our aim is to offer it as an executable component that could be reused by many different CLFPs, in the form of an user-friendly, configurable learning service. This service could be also integrated into the existing LD editing and management systems.

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Kayler, M., & Weller, K. (2007). Pedagogy, Self-Assessment, and Online Discussion Groups. *Educational Technology & Society*, 10 (1), 136-147.

Pedagogy, Self-Assessment, and Online Discussion Groups

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ABSTRACT

One Master's Program, Initiatives in Educational Transformation, has integrated a computer management system (WebCT) into a learner-centered (Weimer, 2002) community of K–12 practicing teachers. Online discussions were an extension of instructional practices that supported dialogue, reflection, and self-assessment for the purpose of continuous professional improvement and facilitating independent learners. The research question that guided this study was, how can we develop self-monitoring and acceptance of online discussions so that students become independent learners? Online discussion postings and student self-assessment served as data sources. Three dominant themes emerged from the data. The first theme, Community of Practice: Dialogue Supports Independent Learning, captures the components of Wenger's (2005) community of practice that enhance students' personal and professional experiences in shaping online discussions. The second theme, Independent Learners: Making Sense of Theory, addresses how educational theory, classroom pedagogical practices, dialogue, and lived experiences support the transformation of practice. A third theme, Self-Assessment Informs Understanding of Self and Discussion-Group Dynamics, conveys the ways in which self-assessment informs students of their strengths, and student-identified areas of improvement support independent learners as well as foster deepened understanding of participation within online discussion groups. Online Communities of Practice (CoP) support students' professional sharing and the development of independent learners. Faculty played an important role in structuring student reflection and self-assessment opportunities to enhance the learning experiences for students.

Keywords

Online discussion groups, Communities of practice, Learner-centered theory, Self-assessment, Social construction of knowledge

Introduction

In a master's program for practicing K–12 teachers (whom we refer to as students) we have combined learner-centered principles (Weimer, 2002) with a commitment to developing independent learners and students' capacity for transformative dialogue. We were anxious to create an effective, supportive learning community among program participants. Commitment to the learner-centered principles led us to involve students in the assessment of the pedagogy. In this paper, we report on the first round of assessment in our efforts to facilitate independent learning within a community of practice (CoP).

We began this project with the belief that we would foster students becoming independent learners if we created among them discussions that focused on expertise gained through classroom practice. The behaviors we were looking for in students were: setting a professional agenda in their discussions, making connections between their classroom practice and readings in the program, and giving and receiving critical feedback in ways that improved classroom practice. In part, these beliefs derive from Dewey's (1916) notion of knowledge construction as a social process. In the context of our program, in which we have intermittent in-person class meetings, we wanted the discussions to be online. Dabbagh and Bannan-Ritland (2005) suggest "online learning is an open- and distributed-learning environment that uses pedagogical tools enabled by Internet and Web-based technologies to facilitate learning and knowledge-building through meaningful action and interaction" (p. 15).

We were highly conscious of the process of creating an effective, supportive learning community around our online discussions. Odin (2002) states, "in an effective learning community, the instructional tasks are contextualized in authentic situations, and students are given opportunities to construct knowledge as they test their ideas on others and evaluate other perspectives" (p. 2). For the purpose of this study, "communities of practice (CoP) is defined as a group of people bound together by shared expertise and passion or a joint enterprise" (Wenger & Snyder, 2000, p. 139). Communities of practice are specialized learning communities defined by the knowledge, not the task. The domain of the CoP is the shared understanding of purpose and value to members that allows members to decide what is worth sharing, how to present their ideas, and which activities to pursue, and include complex and long-standing issues that require sustained learning (Wenger, McDermott & Snyder, 2002).

The *Work Group of the American Psychological Association's Board of Educational Affairs (BEA)* (1993) states, "learning and self-esteem are heightened when individuals are in respectful and caring relationships with others who see their potential, genuinely appreciate their unique talents, and accept them as individuals" (p. 8). Online discussion groups provided a space for purposeful dialogue, supporting the development of a dynamic learning community. Dialogue enhanced and enriched students' understandings of the content. Wink (2000) defines dialogue as a change-agent which changes us and our context. She states that dialogue creates and recreates multiple understandings (p. 47). In particular, we were committed to helping the students develop higher level thinking and processing skills so that their online postings went beyond "story telling" to comparative analysis, evaluation, and application of alternative positions and strategies.

For the purpose of this paper we will share our pedagogy and ways in which we have integrated a computer management system (WebCT) to facilitate the development of independent learners, foster dialogue, and provide a self-assessment opportunity for students through online discussion groups for the purpose of social construction of knowledge. We made the deliberate decision not to participate in these discussions and we monitored them only loosely. On the other hand, the discussions played an important role for our class and curriculum. Online discussions potentially provide the glue, along with team meetings, that hold the program together between class meetings. What we needed was for students to buy into the process and become independent learners. Our research question that guided this study was, how can we develop self-monitoring and acceptance of online discussions so that students become independent learners?

Context of Our Study

The Initiatives in Educational Transformation (IET) experience is a two-year, non-traditional, school-based Master's program for practicing teachers in PK–12 positions. Interdisciplinary teaching teams (typically 3–5 members) serve as instructors who collaboratively construct and scaffold learning experiences that promote teacher engagement and professional growth. Students enrolled in IET's master's program are diverse in many ways: ethnicity, age, years of teaching experience, gender, elementary and secondary backgrounds, and their work within a variety of educational contexts. IET recognizes the value and importance of collaboration (Cole & Knowles, 2000); therefore, students enroll and participate in the program in school teams of two to six members. School teams typically consist of students who teach at the same school; however, there are multi-school teams as well. School teams meet weekly to discuss and reflect upon the readings and classroom/school issues and share expertise and personal experiences. Teaming provides the context for intellectual community, dialogue, social support, and professional growth. Students gain the perspectives of others and construct positions on crucial aspects of teaching and learning (Kayler, 2004). Collaboration combats the isolation and alienation many students face within schools.

The program supports practicing students with a unique schedule. Our students participate in two two-week intensive summer sessions and 16 eight-hour classes over a period of two years, with a final one-week intensive summer session. Because of our unique schedule of class days, the amount of time students interact face-to-face is limited to classroom meeting time. As part of our curriculum, we implemented online discussion groups using a commercial courseware (WebCT). This web-based learning community expanded teacher-interaction time and classroom pedagogy to include the times we were not meeting face-to-face. We view integrated technology as a way to support and enrich course curriculum in ways that are personally meaningful to students.

WebCT Overview and Implementation

Within a learner-centered (Weimer, 2002) and critical pedagogy framework (Wink, 2000) we organized course content and instructional opportunities using a variety of pedagogical strategies to address diverse learning styles. Our students grappled with constructing meaning from course content and educational theory. We asked them to use the content and theory as they sought to make meaning of their personal and professional experiences, perceptions, and work in schools.

As with any technology-supported program, the class was composed of students with a wide range of abilities, which we challenged them to expand. We worked to scaffold and support students' online skills by providing technology assistance and training several class days. Individual members of school teams also provided technology support to one another and to other school teams. Peer collaboration assisted those with fewer technological skills, enhancing the sense of community and providing needed support.

WebCT supported students through a variety of capabilities or features. For example, all students created individual home pages so class members could learn about each other. They used the mail system within WebCT to contact each other and faculty. Course assignments were managed through the use of an electronic drop box. School teams collaboratively developed a team web page for the purpose of displaying their school and community culture and posted syntheses of teamwork projects and team norms they developed to guide the ways they would work together as a team. Students also participated in pre-configured online discussion groups.

The WebCT online discussion groups were a tool we used as an extension of our classroom to connect individuals and school teams beyond classroom experiences. We configured discussion groups of approximately 8–10 members. Discussion groups were purposely configured so that school team members were not together. School context, grade levels, years of teaching experience, and diversity guided the formation of discussion groups to provide a range of perspectives. This arrangement extended conversations across teams and schools to the broader peer group for the purpose of enhancing team discussions. Vygotsky's (1978) social development theory is based on the idea that social interaction is vital to cognitive development. A second aspect of Vygotsky's theory is the idea that the potential for cognitive development depends on the "zone of proximal development" (ZPD): a level of development attained when learners engage in social behaviors with those slightly ahead of them developmentally. The range of skill that can be developed with guidance or peer collaboration exceeds what can be attained alone.

Situated learning is a theory of knowledge acquisition. Lave and Wenger (1991) suggest that learning requires social interaction and collaboration. Learning occurs as a function of activity, context, and culture in which it occurs. Knowledge needs to be presented in authentic settings with applications that would normally require that knowledge. Learning must take place in a real setting, a setting meaningful to the learner; one that is not contrived. Social interaction is a key component of situated learning. Students posted weekly discussion entries and read the entries of others in the discussion group. Timely postings were considered to be a necessary component in building a community of practice. Each member of the discussion group served as moderator for one week during a 10-week discussion period. Online discussions, classroom experiences, and readings provided the raw materials for class exercises, teacher classroom research papers, and other course requirements. Students were encouraged to integrate these components within their postings. Discussion groups served as a forum for students to be reflective about their own and others' experiences. Students were expected to give a critical analysis of others' ideas in a constructive, professional manner.

The goal for dialogue is to refine the manner and level for which the students engage as professionals and develop as independent learners. Students were provided a space to discuss and grapple with the complexities of teaching and learning, foster alternative perspectives and apply educational theory to practice. Students engaged in dialogue around issues of culture, classroom research, and course texts and regulated their learning as a way to promote accountability to their group and to self-assess. As a faculty we chose to monitor but did not participate in these discussions to guard against our voices overpowering the voices students. Weimer (2002) suggests, "in the classrooms of critical pedagogues, teacher authority figures do not dispense knowledge" (p. 9). We viewed online discussions as a distribution of power in our classroom. Our goal was to both build community within the program and to foster discussions beyond school teams promoting the development of independent learners. Online discussion groups were an extension of the classroom, a place for students to share personal experiences and professional expertise, to make sense of curriculum and to participate in communities of practice (Wenger 2005).

Methodology

Data Source and Analysis

One program goal is to allow students multiple opportunities to self-assess based on authentic data. For this study we examined the use of self-assessment and accountability specifically in our online discussions. We provided time and structured a two-step process to allow students an opportunity to reflect on their individual contributions and identify their strengths and areas for improving future discussion participation based on course objectives.

The student self-assessment form took many iterations; the final version included a scale response and asked students to substantiate their score with evidence from their discussion group postings. Students' self-assessment forms were collected, copied, and presented as a data source.

After the completion of the first 10-week discussion, students were asked to bring in a copy of all of their postings from a specific class day. The first step had a two-fold purpose: the first was to give students another opportunity to code and analyze data and identify themes that emerged from their contributions to their discussion group. The second purpose was to allow students to see how they were transferring theory into practice and the ways in which they were contributing to others' understanding.

The next step asked students to evaluate their participation using a scale of 1–5, with 1 being strongly disagree to 5 being strongly agree. Students were also asked to provide evidence of their ranking with quotes from their postings or to provide anecdotal notes. Students analyzed their online postings based on the following:
1. Postings included engaging questions which lead to continued dialogue.
2. Postings demonstrated a knowledge and understanding of assigned readings.
3. Responses were not limited to "I agree" or "great idea" but were supported with examples from personal and professional experiences.
4. Postings offered different perspectives for the group to consider and encouraged dialogue within the discussion group.
5. Participation was timely and on a weekly.
6. Postings were well-written, incorporating proper grammar, spelling, and sentence structure.
7. Other Comments

A total of 63 students, 54 females and 9 males, completed the form and coding process. Each question on the online participation form was entered into a database/chart by a doctoral graduate assistant. She coded the data at the conclusion of creating each chart. We each read and reread the data prior to coding each of the six charts and compared our patterns and themes. Afterwards, we met to compare and again refine our collective analyses. Several broad categories were identified using the constant comparison method (Bogdan and Biklen, 1992). We then used a cluster analysis to further refine the categories.

During the first coding process it was necessary to examine a secondary source of data. It became apparent that some students using the online format took agency: they felt enabled and empowered to act and solve their own problems, and thus had positive experiences. Others did not take agency but adopted a passive role and thus had negative experiences. As a research team we have collected data on each student's learning-style preferences, which upon correlation were important to analyzing specific responses.

What follows next are three dominant themes that emerged from the data. The first theme, Community of Practice: Dialogue Supports Independent Learning, captures the components of Wenger's (2005) community of practice that enhance students' personal and professional experiences in shaping online discussions. The second theme, Independent Learners: Making Sense of Theory, addresses how educational theory, classroom pedagogical practices, dialogue, and lived experiences support the transformation of practice. A third theme, Self-Assessment Informs Understanding of Self and Discussion-Group Dynamics, conveys the ways in which self-assessment informs students of their strengths, and student-identified areas of improvement support independent learners as well as foster deepened understanding of participation within online discussion groups.

Findings

We imagined that as students wrote about their personal experiences, they would develop their own voices and perspectives. Further, we are aware of the power of professional dialogue among students in fostering their professional development. Because we wanted students to theorize their work as well as to share and reflect on it, we structured the online discussions explicitly to make ties among these elements of learning. Previous experience with online discussions had taught us that students are most fluent and confident when they focus on their experience. The processes that develop trust among participants and confidence to generate dialogue are complex. Participants are at different points of professional development and bring different skills and levels of confidence to the process. These assessments add rich data to our developing understanding of the processes.

Community of Practice: Dialogue Supports Independent Learning

Dialogue within communities of practice can play a critical role in the development of independent learners. Wink (2000) views dialogue as, "… profound, wise, insightful conversation. Dialogue is two-way, interactive visiting. Dialogue has periods of lots of noise as people share and lots of silence as people muse. It moves its participants along the learning curve to that uncomfortable place of relearning and unlearning. It can move people to wonderful new levels of knowledge; it can transform relations; it can change things" (p. 47–48). According to Wenger (2005), communities of practice have a commitment to transformation when individuals work towards developing their expertise of practice. Online discussions can be a vehicle for teaching and learning that may not be possible to achieve in the classroom. Placing students at the center of their learning can support their development as independent learners. Our research provides authentic ways in which students supported their own and others' professional development.

Our online discussions were rich in descriptions of the ways in which students used their personal and professional experiences to enhance and enrich online discussions while participating in a community of practice. The majority of students reported enjoying learning about members' experiences and used their own experiences to support their ideas within their postings. They could make connections between their own experiences and the experiences of other participants in order to encourage and be supportive of one another as noted in the following three examples:

- "When a group member wrote about a situation that was similar to my own, I wrote about the way I handled the situation and sometimes offered suggestions for group members to try."
- "I tried to incorporate my classroom and professional experiences as much as possible with the intent (hopefully) of helping some of my teammates know they're not alone."
- "In my postings I tried to begin with a subject that I was grappling with or interested in. I usually discussed the subject, made a connection to my own practice, and then asked questions or asked for opinions."

Students' comfort with sharing experiences enabled them to be supportive and encouraging of one another as they worked to understand and learn from one another. According to Wenger's (1998) perspective of social theory of learning, this community of practice integrated meaning, practice, community, and identity while referring to a familiar experience.

Students served as a resource when they shared their stories. Communities of practice are fostered when students discover that they face similar issues and opportunities. Participants produce a shared practice as members engaged in a collective process of learning. Students wrote:

- "Postings allowed us to seek advice from other colleagues, which is helpful. Postings also allowed us to see that many of us were grappling with the same concerns. Many postings lead to other interesting ideas on which we were able to give feedback."
- "Looking back, I find that I used personal and/or professional experiences in every posting. My fear is that I used too many personal examples and should have focused more on 'theory' input. Many times I discussed learning centers and other strategies that worked very well in my classroom or grade level. I also discussed time constraints, asking if others' experiences were similar."
- "I think my postings were engaging, and some had questions. There was a lot of dialogue on the homework issue and the inclusion discussions. But I do not see that we really got into a lot of dialogue as a group."

Professional expertise was valued as participants drew upon their experiences to help problem-solve real issues our students faced within their classrooms and school contexts. It was not uncommon for students to specifically mention the ways in which they teach particular content and shared their experiences using a variety of methods and strategies. One student reported, "I was very direct about explaining my position with evidence from my own experiences. I talked about my experiences with professional development, my math class, my struggles with SOL scores, and much more."

Some students reported on their lack of confidence in the value of their perspective to others in their discussion groups. For example, one student wrote, “I lack a bit of confidence. I am working on believing that other teachers (especially those with more experience) will value my opinion.”

These students were able to draw upon their understanding of teaching and learning, curriculum work, and experiences in working with peers, parents, and administrators, which enriched the discussion groups. Of the 63 students only two did not include personal or professional experiences in their discussion postings. Most students were able to draw upon their personal and professional experiences as a way to create a supportive CoP. Students served as resources and problem-solvers, and encouraged one another as they worked to understand the ways in which personal and professional experiences can shape their work in classrooms and schools.

Stage, Muller, Kinzie, and Simmons (1998) state, “from a constructive perspective, knowledge cannot simply be given to students; students must construct their own meanings” (p. 35). Online discussions can support cognitive learning through the integration of pedagogy, text, and experience. Students assimilated knowledge and gained deepened understandings while grappling with theory and the social construction of knowledge in the company of their peers. Affective value is found in the development of teacher confidence and contributions to the learning community. The social construction of knowledge embedded in dialogue creates new opportunities for self-reflection, growth, and intrinsic motivation for belonging to a CoP. Online discussions are were a venue for students to incorporate personally meaningful goals, discover and construct meaning from information, and process goals through the learners’ own perceptions, thoughts, and feelings.

Our work supports Wenger’s (1998) belief that CoP fulfills a number of functions in the creation, accumulation, and diffusion of knowledge and the exchange of interpretation of information. A CoP has a shared practice and a common set of situations, problems, and perspectives. There is specific knowledge that the community develops, shares, and maintains (Wenger, McDermott, and Snyder, 2002). Our students worked together and independently created knowledge within an environment that fostered mutual respect and trust. Our study contributes to the knowledge base by illustrating how students work to transform their practice by participating in a community of practice.

Independent Learners: Making Sense of Theory

The American Psychological Association (1993) states that learners “link new information with existing and future-oriented knowledge in uniquely meaningful ways.” The work of teachers, as they strive to meet the learning needs of their students, is difficult. Online discussions validate successes and provide hope and support as students seek solutions and work towards improvement. Students’ personal and professional backgrounds provide a basis for their learning and interpretations.

One quality we value is for students to theorize their classroom practices through making connections with the theories they encounter in the readings. While students had rich discussions in sharing their personal and professional experiences, many of them struggled in making connections to course readings and theory. The more experienced writers and analysts reported they were able to incorporate course readings into their discussions. For example:

- “I felt very connected to the group in this area. We discussed moral issues well and brought in ideas from the readings. I was very engaged in the Teacher Narrative reading and Action Research. We also discussed Weimer. Having common vocabulary made posting easier.”
- “My responses frequently reflected the assigned readings, as well as outside sources of information. I discovered that I used a lot of the language and quotes from the readings to support my thoughts.”

On the other hand, the majority of students struggled or didn’t refer to readings in their discussion postings. When readings were used, however, students would include a quote or two to support their posting. For example:

> The only required text I discussed was the school culture book. I think the reason being is I really enjoyed it. I found myself discussing one book that wasn’t a required reading, just a book I was reading for pleasure. I think next forum I will have my journal with me because that’s where I refer to the texts.

Other students reported on how it was easier for them to respond to others' postings when they had included information from a particular reading. One student reported, "When others quote the text/readings, I easily expand and share my own thoughts, but I find it difficult to connect to the text myself."

For some students, incorporating readings into their postings was a relatively easy task, but for most students this proved challenging. Students reported on the ways in which they wrestled with integrating course readings into their discussion postings:

- "Although I understood the readings, I don't feel that a lot of the postings allowed me to demonstrate this knowledge. The only time I was able to demonstrate it was when readings were brought up in the discussions, which did not occur to frequently."
- "I don't pull in enough connections to the texts we are reading. They are embedded in my thoughts but not evident in my postings."

Regardless of whether students incorporated readings into their discussions or not, they did report developing a language to talk about their experiences. For example:

- "Sometimes I used vocabulary from the readings in my postings."
- "I discovered that I used a lot of language and quotes from the readings to support my thoughts."
- "I discussed the readings and related them to my own life. However, I also asked questions about them for others to clarify things."

Students identified the ways in which they were able to integrate course readings into their postings and the ways in which they used language and quotes to support their postings. Students worked together to make sense of the readings and socially construct understandings. Dabbagh & Bannan-Ritland (2005) conveyed Barab, Thomas, and Merrill's (2001) study that this further supports the notion that the online context can support learners engaged in deep and meaningful interpersonal interaction…. The most meaningful learning for students seemed to occur when they shared personal experiences related to course content" (p. 86). Even where students were not able to use the reading, they were active participants in generating discussions and offering alternative perspectives to one another. Some students primarily identified their own individual perspective as being alternative because of their age, grade level, content area expertise, and years of experience when offering their perspective:

- "I think my postings were very different because I am a PE teacher and the others are all classroom teachers. I had many different perspectives and ways of doing things that a classroom teacher would never have."
- "My writing appeared to be more conservative than that of my fellow group members. This may be due more to my age than beliefs."

One way that students promoted alternative perspective-taking was to play the role of devil's advocate or to ask thought-provoking questions. As one student wrote, "Questions that lead to discussions are typically questions that are controversial. I based my questions on controversial class topics."

Several students reported on how they lacked confidence or felt nervous about how their postings might appear confrontational to their peers. One student wrote, "I talked about 'courage' — not in a 'confrontational mode' (like the entry about people not getting along with peers at their schools) but in beautiful examples of child/staff/parents — those who feel marginalized or challenged. My entry about Thad!"

Student perspectives and sharing enhanced their understanding by providing them opportunities to ask questions of one another, articulate their own perspectives and views, and learn about how others' perspectives can provide new insights into teaching and learning. Students were afforded opportunities to develop skills as they worked to encourage each other, explore alternative perspectives, and make sense of educational theory.

As students developed as independent learners, their capacity to create and use knowledge increased as they participated in shared endeavors with others, all playing active but often varying roles (Rogoff, 1994). For example, some students tried to generate meaningful discussion but failed to engage the discussion group. Students wrote:

- "I felt that my postings did offer different perspectives. I tried to suggest other alternatives and solutions to dilemmas."
- "There's a real contradiction here, for although I feel my postings were relevant and thought-provoking, very little response was generated from them."

- “I did not include as many questions in my postings as I could have — many times I felt there were no more important questions about the topic left to ask. I had difficulty formulating different questions about someone else’s topic. However, I did try to end my entries with room to lead to other dialogue. Plus, I feel my moderating week was filled with engaging questions.”
- “I thought my postings did, but I’m not quite sure they encouraged dialogue within the group. For example, I’d end with a question hoping to carry out or expand the discussion and this did not happen. I think some people dominated the postings.”

Two students did not offer different perspectives but responded only to discussion postings they agreed with and didn’t provide alternative perspectives within the discussion groups.

Overall, students were engaged in discussions and gained alternative perspectives through their grappling with course readings and theory. Students worked together to make sense of theory by offering interpretations and connecting theory to real-life experiences. One key element of CoP is improving one’s ability to transform based on evolvement in a CoP (Wenger 2005). Clearly our students shared similar challenges, interacted regularly, and learned from each other. Their developing language enhanced their ability to articulate and address challenges as they wrestled with educational theory. Students moved to higher-order thinking, and their experiences to develop expertise of practice and ongoing transformation indicates that they are independent learners (Wink, 2000). However, not all students reached the heights of dialogue we hoped they would achieve in this context. These data have fostered our developing understanding of the complex relations between the students’ level of professional development and their capacity to converse with each other about theory within a learner-centered context.

Self-Assessment Informs Understandings of Self and Discussion Group Dynamics

It is important for faculty to structure learning opportunities for students and to discuss the value of self-assessments. Weimer (2002) states, “the literature on self-directed learning also underscores the importance of assessment, only in this case it is the ability of students to self-assess accurately. Sophisticated learners know when they do or do not understand something. They can review a performance and identify what needs improvement. They know when their lack of objectivity necessitates their soliciting external feedback” (p. 17). Our formative self-assessment promoted students to be self-reflective regarding their contributions the development of the discussion community. Data from student self-assessment illustrated the ways in which student contributions positively impacted discussion groups. Students developed awareness that their individual contributions were of value to the learning community and identified ways to enhance the online discussion groups to make them more meaningful to the members. Students also identified areas for improvement. Self-reflection allowed students to evaluate their work and use their postings as evidence to identify patterns of participation which could enhance the larger learning community.

The process of self-assessment based on re-reading and coding their contributions allowed students to reflect on their level and degree of participation and on the quality of their contributions. Their online discussion entries documented the ways in which they participated in their discussion group. The self-assessment activity asked them to focus on two areas: individual contribution and group dynamics.

The self-assessments allowed students to identify strengths and areas to improve upon while fulfilling online-discussion expectations. They were able to get an overview of their contribution, highlighting what they included and what they omitted. Comparing to our criteria and reflecting on what they had actually written, they could not invent what was not there. They recognized and articulated strengths and omissions:

- “I need to reflect more on my actual instruction of the classroom. I’ve spent a lot of time focusing on school culture. I need to be more honest and reflect on myself.”
- “I did not include as many questions in my postings as I could have — many times I felt there were no more important questions about the topic left to ask. I had difficulty formulating different questions about someone else’s topic. However, I did try to end my entries with room to lead to other dialogue. Plus, I feel my moderating week was filled with engaging questions.”
- “I was surprised when reading all of my postings how much more I got out of the discussions than I ever realized. When highlighting, it was evident that I really was on the right track; I was proud of myself. I have a few areas to improve upon but overall I feel that I did a good job with the WebCT postings.”

The program seeks to help students develop skills and capacities that will enable them to engage in activities that will sustain their professional development and facilitate independent learning after the program ends. The capacity to be self-critical and to use data from one's practice to formulate ways to improve is an important element in the capacity for continuous improvement.

Interestingly, we found that while most students reported having an overall positive discussion-group experience, when we examined data pertaining to learning-style preferences, we found that writing could be a factor. When groups included individuals who enjoyed the written-reflection aspect of online discussions, these students were at times frustrated with the lack of participation and depth given by others. We also found that those who enjoyed writing were more willing to problem-solve and self-evaluate their contributions.

Typical areas of difficulty mentioned by the students were related to finding time to post regularly to simulate an ongoing discussion and the lack of connection between personal/professional experiences and issues in the readings. The data revealed that students in functional discussion groups were able to determine and connect the positive interactions and needs for improvement from a personal perspective:

- "I enjoyed talking with my discussion group. It was hard to find time each week to write, but when I did the ideas just flowed."
- "I liked posting my ideas on WebCT but I wish the caliber of writing was stronger and that the discussions were a bit more lively, intellectually-based. I feel that much of it was warm-fuzzy, "you go girl" type of writing."

Another group of students called for changes in membership in their discussion group. Interestingly, this group of students identified similar issues of participation and quality as areas of frustration:

- "I hope we fix our group. There was lack of participation and organization in my group. Need to discuss a format."
- "I would like to see the groups changed. I didn't like our group. Very negative and few postings! I checked almost nightly and rarely had something to respond to. The same few were always posting, while others rarely did."

In examining these students' learning-style-preference data, it was evident that they were less inclined towards written reflection as an engaging learning tool. It is likely that these two students would have positively engaged in face-to-face oral discussions as a preferred learning style. These students were unable to look inward to their own role in shaping the learning community but rather focused outwardly to the participation of others as inadequate. In comparison to the earlier group, these students viewed their negative experiences as the fault of others in the group and failed to identify their role in the dysfunction of the group.

Based on student self-assessment data we made some changes in group configurations and redesigned the second self-assessment form to include group accountability. Students were given the choice of maintaining or modifying their current discussion groups or creating new discussion groups. In the second self-assessment survey, we framed our questions to elicit data in three areas: students' use of critical pedagogy; what they valued most about online discussion; and accountability. Students individually self-assessed their contributions, and then met with their discussion group to discuss evidence that members were engaged in dialogue and to identify areas of improvement. This enabled us to increase inter-accountability among group members while allowing face-to-face conversations to meet the needs of diverse learners.

Overall, students who had either positive or negative experiences with their discussion groups identified similar issues: lack of participation and lack of depth in individual contributions clearly impacted the learning experience. Different modalities of dialogue were evident based on these four students' self-assessments. The role of self-monitoring, reflection on discussion postings, and self-evaluation facilitated students to critically examine their role within the discussion group and its implications.

Conclusions and Implications

Online communities of practice offer much to the learner in terms of cognitive and affective development and opportunities for growth as independent learners. Online communities offer students opportunities to practice newly acquired language in a supportive environment with peers. In our study, students worked together to create new understandings and constructed knowledge as they engaged in making sense of educational theory. Students' expertise developed as they built upon each others' understanding and worked within their zone of proximal development (Vygotsky, 1978). Students supported and challenged one another as they worked to become independent learners and deepen their knowledge base. Learning was meaningful as students were able to tailor their learning to topics/interests that were worthwhile to themselves. Students were able to ask questions or present ideas that they may not have within the larger class or in another format. Students came to know each other as individuals and formed learning relationships that provided affective support that further aided their learning and development.

Students' professional learning is supported within a CoP, which integrated technology into a learner-centered curriculum. Students were afforded multiple opportunities for professional sharing. By faculty constructing relatively small online discussion groups, students were able to share ideas and expertise within a supportive community. Students' personal and professional experiences enhanced discussions as students learned about each other's experiences. Students demonstrated a willingness to share, which enhanced their participation within the discussion groups. Students have specialized knowledge and expertise from their personal experiences and work in schools. Sharing this expertise can enrich the lives of teachers and provide practical solutions to classroom issues. Through dialogue, students generated new understanding about self, collaboration, teaching, and learning. While students worked together they were able to share their experiences, which helped validate and support others. Students provided one another with social and emotional support as well as multiple resources, which created a safe, reciprocal, and trusting learning environment. Online discussions can help sustain, extend, and support students' learning within a community of practice. Our research examined authentic student contributions centered on learner-centered theory to facilitate and support the development of independent learners.

Online CoP can support the development of independent learners. Students shaped their communities around topics or issues that were important to the members. We believe online discussions can encourage autonomy as students choose what to discuss and when, or even whether to enter into an existing discussion topic. Our students became more self-directed as learners as they shared unique personal and professional experiences, self-assessed, and sought out solutions. Through online discussions, students were able to explore alternative perspectives, grapple with the tension between educational theory and practice, and thus assimilate knowledge through dialogue. The alternative perspectives gained from classmates working in a variety of positions and school environments provided a spectrum of ideas and solutions. This interactive process was one springboard for developing a shared vocabulary. Students offered one another examples of alternative frameworks and understandings of pedagogical theory in practice. Students also supported each other as they shared successes and wrestled with teaching innovations to transform their teaching practice. Students created their own meaning while building upon existing understandings and beliefs as they collaboratively addressed the realities of classrooms and schools. Placing students at the center of their learning affords learners with a new paradigm that can support their development as independent learners. In our research, we found that CoP, independent learning, and integrating real-world experience combined to create a strong learning experience for students and for faculty.

Faculty need to 1) structure the online learning experience, and 2) build self-assessment into the process. They need to take the necessary time to have clear goals for the purpose of participation and share those with students and carefully think about the ways in which to configure online discussion groupings. We configured our discussion groups to promote alternative perspectives based on school contexts. However, we found that personalities and experiences could either enhance or diminish students' participation. We monitored but did not participate in discussion groups because we felt it was important to allow students to have ownership and to develop their own voices without faculty intervention. It was a challenge for faculty to take a hands-off approach with regard to students' discussions. However, we had a clear hand in designing the online experience that supported student growth. In addition, faculty need to be willing to give up class time in order to support students' developing expertise with the technology, build community, and promote meaningful self-assessment. The authors philosophy to support independent learning, made it difficult to find a supportive assessment model. Some students were not as engaged as others, and this limited their development as independent learners. We needed an authentic way to evaluate our students' participation and a mechanism that would allow our students to make visible the degree to which they participated within a reflective framework. We decided to implement a self-assessment component to make explicit both our expectations and students' understanding of our expectations.

As a result of our first stage of research, it is clear that self-assessment by students should be developed and built into CoP. Individual self-assessment was viewed as one way to authentically address discussion-group dynamics and highlight the importance of individual contributions impacting the learning community. By taking time to assess how discussion-group dynamics were playing out, we discovered that individual self-assessment was one way to address functioning and non-functioning discussion groups. Individuals' number and level of contributions directly influenced the direction and depth of discussions. We suspect that to a large extent positive or negative experience with online discussion is based upon personal learning-style preferences rather than being a function of online learning. The role of learning-style preferences and participation within CoP is an area in need of further investigation. Faculty also needs to be engaged in the reflective process of assessing the ways in which discussion groups' function. Accountability to others is a strong motivator for student participation when working within a supportive, functioning discussion group. In light of our study, we are curious to further explore the following: How do faculty design the affective role of online learning when they have limited or no classroom interaction? How can faculty scaffold higher-order thinking to promote a deeper level of understanding of course content among students with differing levels of expertise and knowledge? How can faculty design self-assessment to not only assess their understanding of their teaching but also the learning of their students?

With regard to students, self-assessment allows them to identify areas of difficulty and problem-solve in order to become more fully engaged and make meaningful contributions to their discussion group. This aspect of self-assessment encourages students to have ownership, voice, and direction of their own learning. Self-assessment brings learning full circle. It is our hope that students' awareness of their quality of contributions shaped their future participation in online discussions. Self-reflection supports the notion of continuous improvement and highlights the importance of individual contributions to a web-based learning community. Awareness of individual contributions and impact on others enhanced online discussion groups and CoP by supporting a learning community designed to facilitate independent learners and the social construction of knowledge.

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Systematic Planning for ICT Integration in Topic Learning

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ABSTRACT

Integrating Information and Communication Technology (ICT) into teaching and learning is a growing area that has attracted many educators' efforts in recent years. Based on the scope of content covered, ICT integration can happen in three different areas: curriculum, topic, and lesson. This paper elaborates upon the concept of ICT integration, and presents a systematic planning model for guiding ICT integration in the topic area. A sample of an ICT integration plan is described in this paper to demonstrate how this model can be applied in practice.

Keywords

ICT, ICT integration, Systematic planning, Integration plan

Introduction

The rapid development of Information and Communication Technology (ICT) has made information ubiquitous and computers cheaper and more powerful. Much evidence indicates that technology has great potential to increase learners' motivation, link learners to various information sources, support collaborative learning, and allow teachers more time for facilitation in classrooms (Moallem, 2003; Roblyer, Edwards, & Havriluk, 2004; Wilson & Lowry, 2000). Integrating ICT into teaching and learning has therefore become a great concern for many educators.

Depending on the scope of content covered, ICT integration can happen in three areas: curriculum (macro), topic (meso), and lesson (micro), as shown in Figure 1. ICT integration into the area of a curriculum normally requires ICT to support a more substantial amount of subject content, such as a complete course containing a number of topics in a specific discipline like science. Examples of such ICT integration are multimedia curricula delivered in CD-ROMs (Wang, 2001) or web-based courses. In the topic area, ICT can be used to cover certain topics within a course. A topic usually involves a series of smaller pockets of knowledge, such as DNA or cell division, which are usually interrelated to elaborate concepts. At the micro level, ICT is used to help explain specific knowledge units, such as DNA within a single lesson.

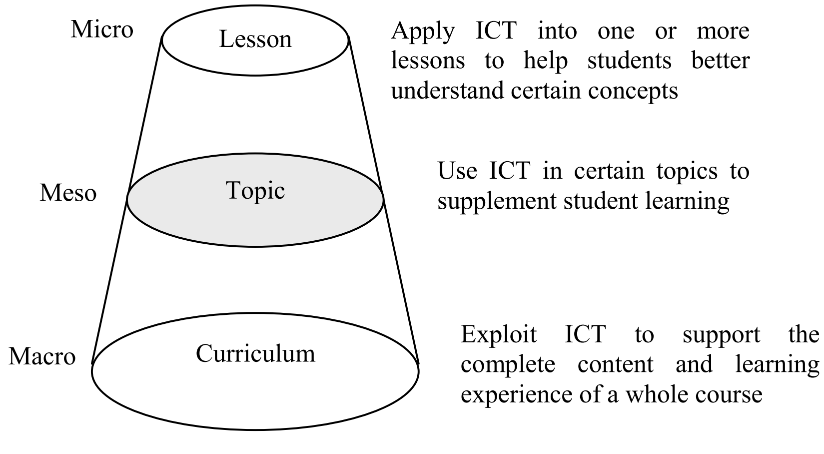

Figure 1: ICT integration areas

This paper demonstrates how a systematic planning model is used to guide teachers, who are called teacher-designers in the paper, in designing their ICT integration plans for a subject topic at the meso level. To help the teacher-designers better understand how to apply this model, a sample of an ICT integration plan that is built upon the systematic planning model is also provided in this paper as an appendix.

The Concept of ICT Integration

Integrating ICT into teaching and learning is not a new concept. It may be as old as other technologies such as radios or televisions. However, with the rapid development of emerging technology, such as web technology, ICT integration has increasingly attracted the attention of educators. In this section, we will elaborate on the terms of ICT and integration separately before giving the definition of ICT integration.

ICT is basically a tool. It can be hardware (such as computers, digital cameras), software (such as Excel, discussion forums), or both. In the educational context, it mainly refers to various resources and tools (software) presented on the computer. ICT is not particularly reserved for education; it is not a panacea for solving all educational problems either. However, it is "certainly a useful tool that enables us to link various learning communities together in new and different ways" (Taylor, 2000, p. 4). Research has indicated that the use of ICT can support new instructional approaches and make hard-to-implement instructional methods such as simulation or cooperative learning more feasible (Roblyer, Edwards, & Havriluk, 2004). Moreover, educators commonly agree that ICT has the potential to improve student learning outcomes and effectiveness if it is used properly (cf. Wang, 2001).

Integration has a sense of completeness or wholeness (Earle, 2002), by which all essential elements of a system are seamlessly combined together to make a whole. In education, simply handing out to students a collection of websites or CD-ROM programs is certainly not ICT integration. In a properly crafted ICT integrated lesson, ICT and other crucial educational components such as content and pedagogy are molded into one entity. As a result, the quality of the lesson would somehow be diminished if the ICT ingredient were taken away from the ICT-integrated lesson (Williams, 2003).

Putting these two words together, ICT integration in this paper is broadly defined as a process of using any ICT (including information resources on the web, multimedia programs in CD-ROMs, learning objects, or other tools) to enhance student learning (Williams, 2003). It is more of a process rather than a product. A simple placement of hardware and/or software will not make integration naturally follow (Earle, 2002). Numerous studies comparing traditional classroom-based instruction with technology-enhanced instruction have found insignificant differences in student satisfaction, attitudes, and learning outcomes (Johnson & Aragon, 2003). The primary factor that influences the effectiveness of learning is not the availability of technology, but the pedagogical design for effective use of ICT (Mandell, Sorge & Russell, 2002). The computer should be fitted into the curriculum, not the curriculum into the computer (Earle, 2002). Therefore, effective ICT integration should focus on pedagogy design by justifying how the technology is used in such a way and why.

Effective ICT integration into the learning process has the potential to engage learners. For instance, using multimedia to present authentic and ill-structured problems in problem-based learning can motivate and challenge students and hence develop their problem-solving skills (Boud & Felleti, 1991; Savery & Duffy, 1995). ICT can support various types of interaction: learner-content, learner-learner, learner-teacher, and learner-interface (Chou, 2003; Moore, 1989). These types of interaction make the learning process more interactive and learners more active and engaged.

Research evidence has also confirmed that effective ICT integration can promote student-engaged learning. For example, in a research study on the uses and effects of mobile computing devices in K–8 classrooms, Swan, Hooft, and Kratcoski (2005) reported that the students' motivation to learn and engagement in learning processes were improved by the use of mobile computing. In another study exploring the use of ICT tools to engage students in higher-order thinking in a Singapore school, Lim and Tay (2003) observed higher students' engagement in higher-order thinking by using ICT tools.

The Systematic Planning Model for ICT Integration

Many instructional design models are currently available to help teacher-designers plan their ICT integration into the curriculum. Some examples are the ASSURE (Analyze learners; State the objective; Select method, media and materials; Require learning participation; Evaluate and revise) model (Heinich, Molenda, Russell, & Smaldino, 2001), the WebQuests model (Dodge, 1997), and the ICARE (Introduction; Connect; Activity; Reflect; Extend) model (Hoffman & Ritchie, 1998). These models show guidelines for incorporating various resources and tools into teaching and learning. However, they do not explicitly encourage teacher-designers to think and justify why these resources and tools are used the way they are.

Figure 2 presents a systematic model for designing ICT-integration plans. It is systematic because it follows a logical flow and has components organized in a rather linear manner. Development of each component in the model depends very much on the completion of its previous components. This model essentially provides an easy-to-follow structure, where designers move to the next component only after they have completed the current component. Most importantly, this model requires teacher-designers to explicitly justify why the technology is used (the Rationale component), and how to effectively incorporate the technology (the Strategies component). The key components of this model are to be explained in detail below.

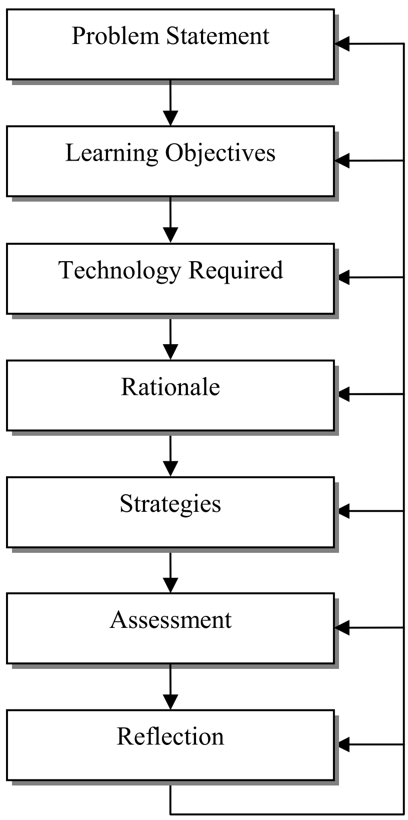

Figure 2: A systematic model for ICT integration

Problem Statement

This systematic model starts with a problem statement, which describes the major problems or issues to be addressed in a topic. For example, in the topic of "Energy," shown in the Appendix, the major problem is "what can we do to prevent energy crises in Singapore in the future?” The problem statement serves as a starting point for the ICT-integration plan. The problem should be authentic, ill-structured, and challenging (Boud & Felleti, 1991). Also, the problem should be relevant to the intended target learners rather than to the teacher-designers. It is too often that the teacher-designers assume that students will understand and buy into the relevance and value of the problem. Unfortunately, the students do not simply take ownership for the problem if it is irrelevant to them (Savery & Duffy, 1995).

Learning Objectives

Learning objectives specify the intended learning outcomes at the end of the topic. Teacher-designers may write learning objectives based on the ABCD model (Reiser & Dick, 1996), where A is Audience; B is Behavior; C is Condition; and D is Degree. For instance, a complete description of a learning objective following the ABCD model might be: *At the end of the topic, the two secondary students should be able to verbally describe the present energy situation in Singapore on a mind map with 100% accuracy.*

In this example, A is “the secondary two students”; B is “verbally describe”; C is “on a mind map”; and D is “with 100% accuracy.” It is worth mentioning that the behavior in a learning-objective statement should be observable and measurable. Vague verbs such as “understand,” “do,” or “brainstorm,” are unsuitable for learning-objective statements. It is sometimes acceptable to omit or simplify one or two of the requirements mentioned. For instance, the D part (“with 100% accuracy”) in the above example may be omitted; the A part can be simplified to “students” if the readers know who the intended audience is.

Technology Required

In order to address the problem and achieve the learning objectives, teacher-designers need to carefully compare all possible technologies that can be used for learning this topic. The technologies in this model may include software such as multimedia courseware, web-based resources, communication tools (such as voice chat, textual discussion forums, or video conferencing), mind tools (such as concept mapping tools and multimedia authoring tools), or any other possible ICT tools.

Rationale for Using the Technology

Technology should be used not because it is available or it has been shown effective in some cases. It should be used to enable the process and enhance learning. Inappropriate use of technology can lead to negative effects (Johnson & Aragon, 2003; Russell, 1999). Teacher-designers need to choose proper technology and justify i) why it is needed for the topic; ii) what added values the technology can offer; and iii) how the technology can support the instructional process. Moreover, Roblyer, Edwards, and Havriluk (2004) suggest the following for rationalizing the use of technology: i) high motivation; ii) unique instructional capabilities such as helping students visualize data/problems or tracking learning progress; iii) support for innovative instructional approaches such as collaborative learning and problem-based learning; and iv) increased teacher productivity and student knowledge construction.

Strategies for Implementation

After determining what technology is needed and why, teacher-designers must now decide how to effectively and meaningfully incorporate the selected technology into the topic learning. Since a topic is usually composed of several lessons, details on ICT integration should be provided separately for each lesson as well as for the entire topic. For each lesson, the teacher-designers should clearly answer the following questions:

- What ICT-based resources such as web sites, CD-ROM programs, or learning objects will be used?
- How will the ICT-based resources be used in various settings such as a full-lab, where each student uses a computer, or half-lab environment, where two students share a computer (Wong & Wettasinghe, 2003)?
- Why should we use these resources this way?
- What tasks/activities will the students do during the lesson?

- Are any handouts or instructions provided?

In addition, for the whole topic, the teacher-designer needs to specify how one lesson connects to the next lesson and the reason for doing so.

Furthermore, when designing an ICT-integration plan, the teacher-designers also need to consider whether:
- The activities can promote students' critical thinking or other higher-order thinking.
- The students understand what they are supposed to learn.
- The expectations and assessment criteria, such as rubrics, are stated clearly.
- There are opportunities for students to take control over content, pace, and sequence.

Student Assessment

Usually at the end of the topic, the students will be assessed on how well they have mastered the topic. The assessment often reflects both the process and the product (Jonassen, 1991). The assessment on the process examines how the students complete the learning activities or tasks, work together to complete the final product, or construct knowledge collaboratively by using the ICT. Methods used for the process assessment include writing online reflection journals, peer evaluation, or e-portfolios (Barret, 2006). The assessment on the product aims at investigating the quality of the final outcome, such as solutions to the problem, or software programs developed. Usually, there are two forms of assessment: ICT-based and non-ICT based. The ICT-based assessment includes computer-based testing, multimedia program development, PowerPoint presentation, Weblog writing, or concept map construction. The non ICT-based assessment involves writing a paper-based essay or a reflection journal, or answering short questions on paper.

Reflections and Further Suggestions

A plan is never good until it is executed and proven right. In the planning process, very often teacher-designers are faced with many constraints and restrictions that limit their choices and strategies. After conducting the ICT-integrated lessons, the teacher-designers need to reflect upon their learning experiences of the ICT integration. The reflections can focus on the appropriateness of the technology used, strengths and weaknesses of the technology, and possible improvement. Additionally, the teacher-designers can also provide further suggestions on how other teachers can use the lessons for different target students in different contexts. These suggestions may include alternative technology, instructional methods and activities, assessment approaches, and ways to improve the integration of ICT. Below are some points to help a teacher-designer reflect upon an integration plan:
- Are the major questions involved in the topic answered?
- Are the activities planned towards achieving the learning objectives?
- Does the technology support the instructional process?
- Is the rationale for using the technology sound?
- Can the implementation process be further improved?
- Are the methods for student assessment valid?
- How can we further improve the use of ICT in the topic?

A Sample ICT Integration Plan

Based on this systematical planning model, a sample of an ICT integration plan is designed as shown in the Appendix. This topic is about energy in the subject of science for the "secondary two" students in Singapore. It is to be completed over two double periods and one online session. Each double period lasts for seventy minutes, and the online session takes about three days.

The main purpose of studying the topic is to make the students realize the current energy situation in Singapore and propose a solution for preventing any possible energy crises in the future. It employs five ICT tools: Internet browser, PowerPoint, Mind Manager, Discussion Forum, and Email system. The reasons for choosing these tools are explained in the rationale section. For instance, the Internet browser allows students to search for and locate the most current information on the Internet; Mind Manager is used to organize and present information.

The learning process is as follows: The students carry out two tasks in the first double-period lesson. The first task is to browse the given website, discuss it in groups, and create a concept map using Mind Manager. The second task is to search for information about possible energy crises for Singapore in 20 years and discuss it in the same group. After the first double-period lesson, an online session is organized, during which the students share their findings regarding both the current energy situation and future energy crises. In addition to participating in the online discussions, the students within a group can also make further clarifications through emailing. In the second double-period session, the students have a face-to-face debriefing on the online discussions, and this is followed by an activity of preparing a presentation on their energy crises prevention solution. Each group gives a presentation during the following week. The detailed description of the ICT-integration plan is attached in the Appendix.

Conclusion

ICT integration is a comprehensive process of applying technology to the curriculum to improve teaching and learning. Its success depends not only on the availability of technology, but also heavily on the pedagogical design. Other factors such as leadership, professional development, time, and evaluation also have a great impact on the effectiveness of ICT integration (Honey, Culp, & Carrigg, 2000). The systematic planning model for ICT integration introduced in this paper is developed to facilitate teacher-designers' producing effective-ICT integration plans for topics in their teaching subjects, and provides rationales and strategies applied in the plans. We hope this paper will inspire some new thoughts into ICT integration for the curriculum of the new era.

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Appendix: A sample of an ICT Integration Plan

Subject: Science	**Student stream/level**: Express/S2
Topic: Energy	**Duration**: Two double periods of 70 minutes each and one online activity outside class hours
Problem Statement	The scarce energy resources we have in Singapore have posed a threat to our long-term survival. What can we do to prevent an energy crisis in the future?
Learning Objectives	At the end of this topic, students should be able to: 1. Visually describe the present energy situation in Singapore on a mind map. 2. State the potential energy crises in Singapore in 20 years. 3. Present in class, using PowerPoint, a solution to prevent energy crises in Singapore.
Technology Level	Intermediate
Technology Required	1. Internet browser for searching information 2. Mind Manager for organizing ideas 3. Presentation tool: PowerPoint 4. Collaboration tool: Blackboard discussion forum 5. Communication tools: Blackboard discussion forum and Email
Rationale for Using the Technology	▪ The most current information on local energy profiles can be found on the Internet. ▪ Ideas can be better organized and presented using Mind Manager. ▪ Collaboration can be done through discussion forums and email. ▪ Ideas and concepts can be more effectively illustrated by PowerPoint
Strategies for Implementation	**Lesson 1 (70 minutes): Knowing the Energy Sources in Singapore** The lesson starts by asking individual students to visit the website http://www.eia.doe.gov/emeu/cabs/singapor.html, where they will find current information that describes the energy situation together with information regarding the development undertaken by both private and governmental agencies to address energy issues in Singapore. Also, students are encouraged to search for other supporting information on the Internet about what will happen to our energy supply 20 years down the road. After searching for information, students are to share and discuss in groups of four their findings about the present energy conditions and any potential energy crises that can happen in 20 years' time. Following the discussion, each group creates a mind map on the present energy conditions by using Mind Manager. Students will discuss their findings on potential energy crises online. **Post Lesson 1 Activity (online): Online Discussions** After Lesson 1, students will take part in online discussions in Blackboard. Each group will post their findings on potential energy crises as a new thread and their mind map as an attachment. Members from other groups are to comment and make critical suggestions. The online discussions will last three days. The teacher will moderate the discussions and may clarify specific issues or problems that individual students have via email. **Lesson 2 (70 minutes): Presentation** In this lesson, students are to come up with a solution for preventing the energy crises from happening in 20 years' time. To connect the last lesson to this lesson, the teacher first gives a debriefing on the students' online discussions and gets the students to discuss their solutions among group members. The teacher will not supply any solution but provide scaffolding instead. The solution files will be showcased in the class "Home Site," which is a repository of students' past assignments. Students are to present their solutions in PowerPoint the following week.
Student Assessment	Students will be assessed on: 1. The mind map. 2. Content, the number of relevant connections, the quality of explanations of their argument, and any examples used to substantiate their ideas. 3. the online discussions

	4. The quantity of postings, clarification, creative thinking, and critical thinking. 5. The PowerPoint presentation. 6. The rationale, practicality, and effectiveness of their solutions.
Reflections and Further Suggestions	For classes which do not have a Home Site, the plan may be modified to allow submission of PowerPoint presentation via soft copy. The teacher may then showcase works that are of exemplary nature in future classroom discussion.

Mbambo, B., & Cronje, J. C. (2007). Learning with a Website for the Textile Industry in Botswana. *Educational Technology & Society*, 10 (1), 157-170.

Learning with a Website for the Textile Industry in Botswana

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ABSTRACT

This paper reports on a locally initiated investigation into the suitability of the Internet in helping to meet the information needs of women in small, medium, and micro enterprises (SMMEs) in the textile industry in Botswana. The background is the stated government policy to encourage the development of SMMEs and the Internet infrastructure. The question is, how likely are women entrepreneurs to use a website as a resource? We considered two barriers to the use of technology by women in developing countries, socio-cultural and physical. To determine the extent to which these could be overcome, a design experiment was conducted in which an information website was created and its use evaluated on a target population consisting of women entrepreneurs in the textile industry in Botswana. Data collection occurred in two phases. Firstly, interviews were conducted and conferences were attended to determine the information needs. Then a website was developed and evaluated by think-aloud protocols, focus groups, and interviews. Initial results indicate that the site was both useful and usable to the target population and that it made some work easier for them. Nevertheless, they need to use the Internet not only to receive information, but also to provide information in order to trade and sell their own goods. This has implications for government policy in terms of enabling credit card-based international trading using the Web.

Keywords

Lifelong learning, Internet usage motives, Computer attitudes, Perceived usefulness; Perceived ease of use

Introduction and background

There are many calls for (and studies reporting) the use of the Internet to speed up the development process in developing countries (World Bank, 1998; Kgegwenyane, 2000; Thaphisa, 2000; UNDP, 2001). The International Centre for Research and Development (IDRC http://www.idrc.ca) of Canada has funded several such studies (IDRC, 2004). Duncombe & Heeks (1999) carried out a study into the use of Information Communication Technology among small-scale businesses in Botswana. The Association of Progressive Communication (APC) and Femnent (2000) conducted a study to establish how African women were using the Internet. Mbambo (1999) did a study on Internet connectivity in Botswana. However, there are few reports of initiatives taken by the people themselves, without any outside financial support.

This paper reports on a study initiated in Botswana to investigate the usefulness of the Internet mainly for women in the textile industry working as small, medium, or micro entrepreneurs. The research population belonged to the Gaborone chapter of the Botswana Textile and Small Business Association (BOTSBOA). The principal investigator was a librarian at the University of Botswana. We sketch the background, give a brief summary of the literature, explain the design and evaluation methodology, and then discuss our findings.

The World Bank and UN agencies have all cited the Internet as a key factor in the development of emerging countries because it offers opportunities for storing and exchanging large quantities of information. In developing countries, however, the cost of the Internet makes it inaccessible to most individuals. "The monthly connection cost of the Internet far exceeds the monthly income of a significant portion of the population" (United States Internet Council, 2000). Other factors that inhibit the use of the Internet in Africa are the very small number of people who own computers, poor telephone infrastructures, a lack of understanding of what the Internet does, and illiteracy (Kole, 1999; Ngwainambi, 2000; United States Internet Council, 2000). In light of such problems and difficulties, what is needed to make the Internet a usable information storage and retrieval tool for people in Africa and other developing areas, and to encourage lifelong learning from unstructured information sources?

Botswana is a relatively rich developing country with a gross domestic product of US$3.5 billion and growth rate of 6.7% for 2003 (Gaolathe, 2004). Its foreign-exchange reserves are enough to pay for imports for the next 26 months. Its telephone density is 17.95% (Government of Botswana, http://www.gov.bw), and the telecom infrastructure includes a subsidiary Internet Service Provider (ISP) called Bosnet, so that an economic and telecommunication infrastructure exists to support Botswana's participation on the Internet. Small, medium, and micro enterprises (SMMES) have been identified as a primary growth sector and engine for economic development in Botswana (Gaolathe, 2004).

Where Ayden & Tasci (2005) developed a quantitative measuring instrument to measure e-readiness in Turkey, we followed a qualitative, participant observation approach. In this case study we investigate the extent to which new users of the World Wide Web (WWW) find an Internet site useful in learning about their business. This paper is predicated on information as a resource in the development process. We focus specifically on the textile sector and investigate the extent to which the WWW can be useful to it. The main question driving the study is: "What are the issues that need to be considered in the use of the Internet for entrepreneurs in Botswana to deliver just-in-time information for learning?" The purpose of the study was not to determine the value or quality of our site, but to use it to investigate the feasibility of the Internet as an information resource for lifelong learning. Any positive or negative comments the users made about the site itself were interesting, but not the point of the study. The point of the study was to ascertain what information needs they had, and the extent to which a Website could meet those needs.

Literature survey

The value of information

The 1948 United Nations Universal Declaration of Human Rights calls for freedom of access to information. It describes such access as one of the basic freedoms of humans. However, information in itself is of questionable value. Although Schram (1964, p. 49) says, "information availability and the wideness of its distribution is directly related to the level of development," Bell (1979) argues that it is content rather than the amount of information that is crucial to the development of society. Rao (1963) and Bell (1979) note that while it is true that economic development leads to an increase in the flow of information through the greater purchasing capacity of people, increased information furthers economic development. On the other hand, Menou (1993, p. 4) contends that "information is no magic recipe for development," as it is erroneously assumed that all information is good for development and that information is free. He concludes "the value of information may lie more in its versatility … than in its straight application to the activities for which it was originally meant" (Menou, 1993, p. 25). In other words, information is valuable, not primarily because it enables one to solve a particular problem, but because it has potential for multi-sectored application. We believe that information should be useful for business and learning.

The Internet as medium for sharing information

According to Schram (1964), the capacity of a medium to spread information efficiently affects the degree of development. The more widely available and accessible information is, the more development may be facilitated. If information is restricted, controlled, highly priced, limited, censored, and constrained, development is unlikely. The availability of information provides a "climate for national development" (Schram, 1964, p. 43). Availability of information is not enough. The information must be used, and people must learn from it. Schram (1964) first demonstrated the relationship between socio-economic development and the type of medium for disseminating information by asserting that every stage of development has its own appropriate media for transmission. Ngwainmbi (2000) argues that there is a relationship among medium, information, and socio-economic development. Cuadrado-Roura and Garcia-Tabuenca (2004, p. 72) put this even more strongly when they write of "[t]he undoubted relationship between ICT development and a scenario of strong urban concentration, high supply of qualified personnel, business head offices, development of business services, etc."

Many have hailed the Internet as the technology that will bring developing economies into the information society (Simpson, 1990; World Bank, 1998; Heeks, 1999, Kirkman & Sachs, 2001, UNDP, 2001), while the United Nations asserts that the Internet will hasten African development (*The Economist*, 2000). Kirkman and Sachs (2001, p. 61) contend that the IT "revolution offers powerful weapons to foster economic growth. It is time developing countries benefited from them." They note that email has proved effective in transmitting vital information about diseases in Africa, and that electronic commerce is fast extending to developing countries. Nevertheless, they also cite many difficulties that hinder the expansion of the Internet in developing countries, such as the lack of national strategies (i.e., neither governments nor private sectors are taking the lead in devising policies for the use of the Internet), inadequate telephone services, a lack of skilled IT workers in African countries, the exclusion of computer education from school curricula, and inadequate resources in schools and universities for IT education. Ochieng (2000) concludes that the possibility that the necessary infrastructure, equipment, education, and attitudes will arise suddenly in the African context is somewhat unrealistic in light of the crippling deficiencies and problems that beset most African countries. While we accept these limitations, this study is aimed at those people in developing countries who are already economically active and could learn to improve their existing businesses, given appropriate access to information.

Information need

In considering the use of the Internet in facilitating lifelong learning, one must determine the information needs of owners of small businesses in developing countries. Table 1 presents an overview of relevant needs assessments by Mchombu (1996), Briscoe (1994), and Heeks (1999).

Table 1. Information needs of owners of small businesses

Mchombu (1996)	Briscoe (1994)	Heeks (1999)
1. Business management	1. Sources of finance	1. External Financing
2. Technical skills	2. Training	2. Trained personnel
3. Financial information	3. Market	3. Management training
4. Legal information	4. Education	4. Source of skilled personnel
5. Marketing information		5. Information that would lead to increased sales
6. Sources of raw materials		6. Existing customers
7. Nursery schools		7. Land or premises
		8. Laws and regulations

From the above table we can see that the needs focus on business, finance, education, and policy.

Since participants in our study were women entrepreneurs, their preferred sources of information (Mchombu 1996) should be considered.

Table 2. Information needs of women entrepreneurs (Mchombu, 1996)

Type of adviser	**Percentage of satisfaction**
Dedicated advisers	55%
Field-service advisers	37.5%
Radio	25%
Local newspapers	7.5%

Table 2 shows that human advisors are highly preferred, while audio is preferred to print. These aspects come into play when considering the Internet, a primarily text-based non-human resource, as a suitable information conduit for women entrepreneurs.

Barriers to accessing information

We must consider what barriers prevent access to information. Not all of these can be overcome by simply putting information onto the Net. We consider two types of barriers, socio-cultural barriers and physical barriers.

For the purpose of this article, we restrict the discussion of socio-cultural barriers to issues of gender, language, and education.

Mchombu (1996) reveals that 40% of the women studied in Botswana did not know where to go for information. Alexander et al. (1983) indicate that the majority of extension service providers were men, which made it difficult for women to freely consult one another when they were intimidated by the presence of "powerful" male advisers. Hopwood (1989), however, indicates that the work and family relationships of women are so intertwined that they leave little time to concentrate on business issues that might be separate from the family. Women have consequently developed informal networks for sharing information. Mbambo (1995) and Mchombu (1996) argue that information provision for women should not be isolated from women's multiple roles but should be related to them in a meaningful way. Sunny and Babikanyisa (1996) indicate that women in the small-scale sector need skills. The proliferation of information advice centres will not provide information for women entrepreneurs (Raseroka 1990). A mechanism that is less male-dominated and therefore not threatening to women should be developed and located in places frequented by women.

However, the literature seems to demonstrate that women are disadvantaged in terms of access to the Internet and that they are largely functionally illiterate. Fewer women than men have access to ICTs (FLAMME, 2000). Marcelle (1998) notes that ICT in Africa is a male-dominated domain, that women are excluded from all levels of employment in the field of ICT, and that women also tend to possess ICT equipment far less frequently than men. Marcelle calls on African countries to re-examine their ICT policies and to make them gender-inclusive. Kole (1999) agrees when she says that limited access to ICT leads to limited access to the Internet and its resources. Schramm (1966) states that education creates a desire for information. Ngwainmbi (2000) shares this view when he states that in Africa, education levels increase in direct proportion to access to computers, the Internet, and current information.

While most of the business literature in collections in Botswana is available in English, the majority of the owners of small businesses in Botswana are Setswana-speaking. This creates a barrier because whatever information is available is not usable to them (Mchombu, 1995). Thirty percent of the population of Botswana is illiterate (UNESCO, 1997). The same percentage has not received any formal education, and so do not speak English. Most of the development information is available in English (Raseroka, 1995). Thus language emerges as a limiting factor in accessing information. Language is also a barrier on the Internet. A *Futurist* editorial states that most African languages are not found on the Internet (*Futurist,* 2000). Everard (1999) adds that the language of the Internet is English and cautions that even simple translations may distort a message. This can limit the extent to which Africans, who are not native speakers of English, can benefit from the Internet.

Physical barriers to accessing information include the lack of infrastructure in particular geographical locations and the inability to manipulate the interface to extract the information.

The Botswana National Library Service Act of 1962 provides a library in each of the major towns and villages in the country. Reading rooms are provided for more remote areas and book boxes are provided for even more remote areas. Information provision in rural areas is the domain of the Botswana National Library Service (Mulindwa, 1987). All other information centers are in Gaborone and Francistown, the two major cities. Concentration of these services in urban centers and the absence of these services in rural areas create a disparity in information service provision (Boadi, 1992). The University of Botswana's Small Business Clinic and other small business information providers are concentrated in Gaborone, which prevents those in rural areas from accessing their resources (Mchombu, 1995). Distance from the capital is therefore a hindrance to access to information. Furthermore, Heeks (1999) indicates that there is a higher telephone density in urban areas than in rural ones — a factor that creates a potential disparity in the provision of ICT in rural areas.

The cost of computers and Internet connectivity far surpasses the monthly wage of the average person in Africa (US Internet Council, 2000). The average African neither owns a computer nor has access to a computer connected to the Internet. Mbambo (1995), Ngwainmbi (2000), and Ticoll (2000) agree that there are serious infrastructural hindrances in Africa. Because telephone communications are poor and the electricity supply is erratic, the Internet is unreliable.

In decoding the interface, literacy, and computer literacy in particular, are important considerations of physical access. However, “in a push-button society a minimum of literacy is needed to know which buttons to push” Galtung (1981, p. 277). Braun (1999) states that illiteracy is the main obstacle to the spread of information in developing countries, but that “Computers and their audio-visual features present great advantages … a mouse click on a visual and a user can listen to information” (Braun, 1999, p. 79). Braun also cites anecdotal evidence from Guatemala that asserts that women market their products on the WWW. Thus, although they are illiterate, they have an opportunity to hear and be heard on the Net.

User acceptance

Simply removing barriers, of course, does not guarantee that the information will be accessed and used. Luarn & Lin (2000) propose the use of the technology acceptance model (TAM) to include perceived credibility, perceived self-efficacy, and perceived financial cost. Aydin & Taski (2005) point out that it is not wise to use the same measurements of e-readiness for emerging countries as for developed countries. Ng’ambi & Brown call for “non-deterministic qualitative approaches to evaluation” (2004, p. 39) and describe their utilisation-focused evaluation, which “does not advocate any particular evaluation content, model, method, theory, or even use” (Ng’ambi & Brown, 2004, p. 39). We subscribe to this pragmatic approach and agree with Collis & Verwijs (1995), who argue that electronic performance support systems should be evaluated specifically for how likely users are to use them. They identify three characteristics that a system should have: It should be useful, it should be usable and it should make the work easier. Cronjé and Barras-Baker (1999) developed this into an assessment rubric with three questions and a number of sub-questions:

- Is the product useful?
    - Does it fit in with the personal work needs of the users?
    - Does the product support and add value to the content?
- Is the product useable?
    - Is the user interface easy to use?
    - Is the product easy to learn?
- Does the product make the work easier?
    - Does it fit in with the work environment?
    - Does it fit in with working procedures?
    - Do the users have the time needed to use it, and does it save time for them?

If the answer to all these questions is “Yes,” then we have a provisional positive answer for the original question, “Is the product likely to be used by the intended users?”

Conceptualisation

Based on the literature surveyed above, it can be argued that information will only contribute to learning and development if it is used. Developing countries have specific physical, infrastructural barriers to information, while unfamiliarity with the Internet also creates interface-related barriers. For women in a developing country, there are particular socio-cultural barriers related to gender, language, and education. The Internet can only be an appropriate medium to overcome these barriers if the target population is likely to use it. The Internet itself could also be a barrier if it is inappropriate, unreachable or not user friendly. Development research aimed at investigating an Internet-based information resource acceptable to entrepreneurs in a developing country should identify the specific information needed to support development. It should also attempt to overcome the barriers that are likely to exist, and increase the likelihood of user acceptance.

Research plan

Our case study was a design experiment (Brown, 1992; Collins, 1992, 1999) conducted over a period of two months. Design experiments are conducted in real life. They allow us to account for multiple variables. They encourage collaboration between researchers and participants to refine and analyze the design. They provide complex social interaction for their subjects. They are flexible and rules can be revised depending on their practical success. At the same time, we can evaluate different aspects of the design in an authentic environment (Collins, 1992, p. 81, Colb et al*.,* 2003). The investigation assessed the information needs of women entrepreneurs in Botswana, considered the likely barriers, developed a website for them, and evaluated the website's usefulness with a methodology based on "future use in practice" (Collis & Verwijs, 1995).

We followed a the first three phases of a four-phase design and development model (Collis & Verwijs, 1995), where the first phase was an "iterative conceptualization of the product and agreement among the design team and representatives of potential users as to what the product should do, be like, and how it will be used" (p. 24), followed by "iterative clarification of the design through rapid prototyping" (p. 24). Phase three saw "beta versions of the product, in a form ready for limited field testing, and formative evaluation of the product" (p. 24). Phase four would have been the releasable version, complete with documentation and support, but for this research only the first three phases were conducted.

We recognize that subjectivity is a constraint in participant research such as this: How do we prevent ourselves from finding what we want to find? In this case, we achieved distance by focusing our evaluation not on the site we built, but on the needs assessment that preceded the creation of the site and on the needs that still existed once the site had been built. Thus, our website is not the subject of the investigation but one of the tools, and we can be objective regarding any information its evaluation yields.

Phase one: Iterative conceptualisation of the product

The first goal was to establish the information needs of the target population and find ways of meeting them. A literature survey was conducted to find out how information is currently being provided. We used a variety of data-gathering instruments such as a questionnaire, interviews, and observations. The questionnaire, developed after the literature survey, asked for demographic information, education level and information needs, and current sources of information.

Much information was obtained by participant observation, as the principal investigator actually joined BOTSBOA and attended their regular monthly meetings. Trade exhibitions were also attended to determine the type of information presented there, as was the launch of the Business Linkages Database (1999) - a joint project of the Fredrick Ebert Foundation and the Ministry of Commerce. The database was created to market the entrepreneurs and their products to government and private organizations.

Phase two: Iterative clarification through rapid prototyping

In applied research such as design experiments, the researcher does not define the problem alone, but in consultation with the participants who say what their problems are (Whyte, Greenwood, & Lazes, 1991). In this case, participants were asked in interviews and focus groups to describe the problems that they experienced in their businesses in trying to gain access to pertinent information. The content of the site was refined, based on their responses. An alpha version of the site was then constructed using Dreamweaver and tested on a few randomly selected individuals for elementary usability. A scaled-down version of the original site can be viewed at http://hagar.up.ac.za/catts/learner/game/1999/buhle/netpage.htm.

Phase three: Formative evaluation of the beta version

Following the procedures suggested by Collis and Verwijs (1995), a beta version was constructed by a professional web-design company and then evaluated by members of the target population. The evaluation questions used were those derived from Collis and Verwijs (1995), and by Cronjé and Barras-Baker (1999) and mentioned in the literature survey. The formative evaluation was done during a regular meeting of the Gaborone chapter of BOTSBOA. Three computers connected to the Internet were made available to members, and the members were observed while they evaluated the site in groups, using a think-aloud protocol to communicate with one another. Afterwards, a focus group discussion was conducted, where the users were debriefed on the value that the site might have for them.

Discussion of findings

This discussion considers the demographics of the potential users who participated in the study. We will then discuss our findings regarding the information needs of the potential users, and how it led to the design of the site. We then consider the extent to which respondents felt that the site could enable women entrepreneurs to overcome the physical information barriers of infrastructure and interface, as well as the socio-cultural barriers of gender, language, and education. We do not claim that any of our findings are specific to women - only that, by chance, our target population consisted entirely of women. Moreover, we do wish in some way to address the common stereotype of women being technologically less aware than men.

Demographics

Of the 858 small, medium, and micro enterprises in Botswana, 106 are textile companies. While the textile sector comprises 12% of the manufacturing sector (Ministry of Commerce, 1999), the Business Linkages Database published in July 2000 by the Fredrick Ebert Foundation lists 295 small-scale textile companies in the country, although some of these may not be registered.

The education levels and access to computer communication of the participants are given in Table 3.

Table 3. Education level and computer access of participants

Education levels	Number	ICT access	Number
Cambridge (fours of secondary-school education)	4	Owns a computer	1
Primary certificate	12	Has access to a computer	2
Junior Certificate (two of secondary education)	8	Does not own a computer	23
Total	24	Has access to the Internet	0

Information needs

From a literature survey (Alexander et al., 1983; Briscoe, 1994; Heeks, 1994, Mchombu 1996), interviews, and meetings, five key information needs were identified: **Markets,** both existing and new; **materials**, which concentrated on obtaining and storing raw and processed materials; **money**, which involved obtaining funding, making money, and financial management; **management**, which incorporated information about land, laws, and logistics; and finally **skills**, which concerned obtaining skilled people and training others.

In the context of a design experiment, the design follows the needs assessment. Once the needs were identified and compared with the literature, a specification of site content could be drawn up, as shown in the following table.

Table 4. Information needs assessment results

Literature synthesis	Stated needs	Site content
Markets	Markets	Markets
Materials	Sources of fabrics	Sources of fabrics
Money	Information on government schemes	Information on government schemes
	Information on writing proposals	Information on writing proposals
Management		Banking
Skills	Information on short courses	Training information

The information needs assessment (Table 4) shows an almost identical mapping between the needs suggested by the literature and the needs expressed by the participants, with the exception of management needs. It was decided to address management needs by incorporating it under training information, and adding information under "Banking" that would include financial management.

Attendance of meetings and participation in the Botswana International Trade Fair and Exhibition led to the realization that a website that simply gives information would not be adequate for our purposes. Entrepreneurs desperately needed places to sell their wares. The website, therefore, would have to include information about any trade fairs in the region to which entrepreneurs could take their products. Similarly, because entrepreneurs stood to gain much if they could market their goods over the Internet, they needed detailed but clear and user-friendly information about how to conduct electronic commerce on the site, although the logistics of making e-commerce possible for them was beyond the scope of this study.

All users said the site covered what they wanted to see - although they added that they would have liked more details about markets in Botswana and the SADC region because these are closer to where they lived and attending such markets would be a viable option. They were disappointed to find that, while all the markets listed on the site were external to Botswana, they could not immediately do business with them.

Users indicated that they would revisit the website for three reasons:

- to get information on markets (60%)
- to advertise goods (20%)
- to learn more about BOTSBOA activities (20%)

When asked what should be added to the site, the respondents all answered together by saying *"e siame",* a Setswana expression meaning, "It is fine." None of the users requested any more information to add to this site, but they wanted a site of real commercial value that would enable them to start trading. This has implications for information provision and what type of information is provided on the WWW. It is not sufficient to provide information that informs potential buyers about where material is located. When buyers receive such information, they should be able to act on it immediately. The subsequent discussion inspired us to discuss all the implications of e-commerce and what they could achieve by means of it.

Physical barriers

Infrastructure: Field work in the form of visits to community centerss and interviews with potential users revealed that the information holdings of existing traditional providers of information (such as libraries, extension offices, and development agencies) were deemed inadequate in terms of currency, accessibility, and responsiveness to the needs of the information society. Most had printed materials such as books, journals, and pamphlets that were housed in buildings and locations that were not easily accessible, because of either distance or hours of operation. It was thus clear that, should it be feasible, the Internet could well present a cheap alternative for providing sufficient and current information.

During the development phase an initial questionnaire revealed that the participants had very little experience with computers and none with the Internet. All the respondents indicated that they had never used a computer program to access business information before. They were, however, technologically enabled in that they could use a telephone and some other electronic devices.

Table 5. Respondents' knowledge of computers (Mbambo & Cronjé, 2002)

Use of computers	True	False
I have never used a computer	60% (6)	40% (4)
I have basic knowledge of computers	40% (4)	60% (6)
I use computers often in my work	0% (0)	100% (10)
I have never used an ATM machine	40% (4)	80% (8)
I use a computer for e-mail	0%	100% (10)
I use a computer for accessing the WWW	0%	100% (10)
I use a computer for word processing	20% (2)	60% (4)
This is the first time I am using the WWW	100% (10)	0% (0)

The results show that participants' computer skills were elementary (Table 5). None of the respondents used a computer at work. None had ever used e-mail. A limited number, 40%, had used a computer for word processing, while 60% had never used one at all, although 80% had used an automatic banking machine.

Users complained that the site took too long to load - even though they obviously enjoyed and liked it when it was finally downloaded and they saw photographs of themselves on the opening page. Several factors may have caused the slowness of the downloading process: The Internet, particularly on a dial-up, is slow in Botswana in the afternoons, and the site contained five photographs on various pages.

Interface: This site had a drop-down index on every page. A good index facilitates the location of information, and users found the index to the site useful for navigation. The index consisted of buttons that led them to their stated information needs. Observation showed that once they discovered what lay behind each button, the entrepreneurs were more eager to find the answers that were catalogued under each heading than to analyze whether the index comprehensively covered all they wanted to know. Thus, for instance, we saw that most were keen to press the button that opened pages about Markets and Sources of material. They were captivated by the fact that the mere press of a button could link them to markets and outlets abroad. The index therefore served to make navigation easy for the users.

Despite the very short exposure of these users to the WWW, users were able to locate precisely what they wanted on the Internet. They were not just interested in manipulating or enjoying the site for its own sake: they wanted the site to deliver commercially.

Socio-cultural aspects

Gender: From observation, it was clear that the participants liked working in groups. The think-aloud protocol revealed that users liked and enjoyed the colors and arrangement of the site. They were particularly amused to see photographs of some of their colleagues on the site. Participant observation revealed that seeing those pictures created a feeling of familiarity and a sense of ownership of the site, which probably helped to eliminate any kind of awkwardness or anxiety that might have accompanied interaction with an unfamiliar technology. Much of this is in keeping with the literature concerning women forming networks to share information, and the call for a less male-dominated information channel (Alexander et al., 1983; Raseroka, 1990; Mbambo, 1995; Mchombu, 1996, Sunny & Babikanyisa, 1996; FLAMME, 2000; Marcelle, 1998). One might deduce from this that when one plans sites for similar groups of people, the inclusion of familiar features on the first page helps to connect people to what is going on and evoke a sense of belonging.

Respondents expressed a desire to have new pictures of their most recent products added to the site (just as photographs of their earlier exhibits had already been included). Because they had been involved in the initial consultation of the site, and had indicated what they would like it to have on the site, they had a degree of familiarity with its content.

Language: During the conceptualization phase, it was drawn to our attention that the language used on the site, namely English, could be a problem for the target population. However, one of the dictates of globalization and international trade practice is that people must communicate with each other in one of the leading colonial European languages. Observation and the use of the think-aloud protocol showed that users could understand the language sufficiently to obtain the required information. The observation further showed that when one member in a group around the computer did not understand, one of her colleagues would translate into Setswana, and the group would continue working.

Education: These entrepreneurs had a limited knowledge of computing and computer-related technologies prior to this exercise. Most of them (60%) had no prior knowledge of computing at all. None of them had used the Internet before this meeting. There clearly is an urgent need to train people in Botswana to use computers if we hope to enable them to use the Internet successfully, even at an elementary level (as was the case in this study). The problem-solving approach observed to be used by the entrepreneurs during the study indicated that their training would need to be informed by adult education theory principles - and that they needed more than mere skills provision. It is also clear that learning in groups would be a valuable methodology for skills transfer.

Conclusions – appropriateness of the World Wide Web for lifelong learning

In the previous section, the information needs of women entrepreneurs in the textile industry were identified. The resultant website was formatively evaluated to determine the extent to which it was likely to assist in overcoming physical and socio-cultural barriers to information. To conclude, the resultant findings are now filtered through the evaluative question suggested by Collis and Verwijs (1995): "Will the product be accepted by the users?" We use the sub-questions devised by Cronjé and Barras-Baker (1999) to structure the following section: "Is the product useful?" Is the product usable?" and "Does the product make the work easier?"

Is the product useful?

Does it fit in with the personal work needs of the users? The site met the expressed information needs of users. It provided information that users had said they would like to have. However, by exposing users to the web it also created new information needs: in particular it created a need for information about how to trade on the Internet. Users do not merelywant to get information. They also want to give information.

Does the product support and add value to the content? Clicking icons on the index and finding important information about possible markets made users realize that the website really worked for them. When respondents said, "It works!: they meant, "This Internet works [for us]!" The users defined what they wanted to see on this site as they went along and used the index to identify each topic and the information that it contained.

Is the product useable?

Is the user interface easy to use? All users said that they found the site easy to use. Observing the users and listening to the think-aloud protocol confirms this. The ongoing tutorial on various buttons also contributed to making the site easy to use. One might have thought that a lack of *any* prior knowledge or experience with the Internet may have been an obstacle, but the simplicity in layout and navigation made it easy for participants to use. Because the index appeared on every screen, it helped users to jump to whatever page they wanted to explore regardless of where they were on the site.

Is the product easy to learn? Internet use may have intimidated some of the participants and inhibited their individual exploration until they were familiar with the site. They were thus soon sufficiently motivated and confident to explore the site in detail, and they were eager to click on the icons that led to information that interested them (such as possible sources of materials and markets for their products).

Does the product make the work easier?

Does it fit in with the work environment? None of the respondents had Internet access in their organizations or at home. This makes it questionable as to whether developing countries should be aggressively pursuing Internet connectivity for the majority. Nevertheless, the benefits of the site (particularly with e-commerce enhancement) might convince users to invest in their own Internet connectivity. The *sharing* of computers in a group obviously helped these users to obtain maximum benefit from the technology. They became one another's lab technicians and instructors. The sharing did not deter them but enhanced the comradeship that made the exploration easier and more fruitful. (Communal sharing is, in any case, a highly regarded community value among African people.)

Does it fit in with working procedures? The site provided access to potential trade partners and to sources of materials in France, Korea, South Africa, and Zambia. Respondents were, however, disappointed to find that they could not immediately trade with those places because they did not have credit cards. The problem here, therefore, is that the working procedures that are beyond the control of the entrepreneurs prevent their continued use of the site. While the Internet can give entrepreneurs ready access to markets and sources of useful raw materials, the population needs to be prepared, through training, access to digitization equipment, and other forms of e-trade readiness, to enable profitable trading and marketing activities. Policy-level cooperation among the Ministry of Trade and Commerce, the private sector and Botswana Telecommunications, and the Bank of Botswana, could pave the path for successful electronic commerce, which more than anything else, is what these entrepreneurs and others need. If e-commerce is to become fully operational and convenient for small-scale businesses in Botswana and elsewhere, appropriate policies enabling Internet accessible free trade will need to be implemented, and exchange controls will need to be relaxed.

Do the users have the time needed to use it and does it save them time? The complaint that the site took too long to load is a valid one, and one that cannot be ignored in web design for developing countries. If a group of users is using a dial-up connection it may not be wise to include too many graphics. Even before one designs a site, one needs to know the about the equipment that the intended audience will be using. The Internet creates a sense of immediacy and anticipation. Users, therefore, are prepared to invest the time needed, but need e-commerce, as it would save them a great deal of time in bringing their products to market.

Recommendations

It has already been established that Botswana is a relatively rich developing country. Its telecommunication infrastructure is one of the best in Southern Africa. However, this case study has shown that there are pockets of people who are not aware of the potential value of the World Wide Web, or what the world is using it for. The population under study was one such group. They were not aware that the Internet had any relevance or value for their business. Yet we saw that the Internet can be a useful information resource for such groups of entrepreneurs.

The lack of computers at the individual, as well as the organizational, level is an obstacle to accessing the Internet. A well-planned and cooperative partnership should be developed between small-scale organizations, such as those involved in this case study, and information centres - with the latter playing the intermediary role in permitting participants to gain access to the Internet.

We also found that it is not enough to merely provide access to information that entrepreneurs need. It is equally important to design a commercially usable site that would facilitate e-commerce. The site needs to go beyond being an information center to one that enables commercial activity such as local and international trading and marketing. Entrepreneurs will return to a service if it sells their goods or if it provides them with material and information that they need. Thus, while respondents have shown their eagerness to engage in e-commerce, they neither have access to the Internet nor credit cards with which to conduct online business. Government policies need to facilitate these amenities for entrepreneurs.

This case study has shown that it is not enough to use the web as an information source. The web needs to be a commercial platform. It has been demonstrated that entrepreneurs are willing to learn to use the WWW in order conduct business and make profits.

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Logic of Sherlock Holmes in Technology Enhanced Learning

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ABSTRACT

Abduction is a method of reasoning that people use under uncertainty in a context in order to come up with new ideas. The use of abduction in this exploratory study is twofold: (i) abduction is a cross-disciplinary analytic tool that can be used to explain certain key aspects of human-computer interaction in advanced Information Society Technology (IST) environments; (ii) abduction is probably the central inferential mechanism at work when learners learn or in general make sense of things in an IST or mobile context. Consequently, abduction illuminates the special epistemological circumstances of IST enhanced learning, in particular when the learning materials and the learning environment have been arranged in accordance with constructivist pedagogical guidelines. A study of abductive reasoning will help us better understand IST enhanced learning and IST user behaviour as well as give us some valuable hints to the design of human-computer interaction in general.

Keywords

Information society technology (IST), Information and communication technology (ICT) enhanced learning, Abductive reasoning, Human-computer interaction (HCI), Constructivism

Introduction

Sherlock Holmes, the hero of Arthur Conan Doyle's novels, often amazed his loyal friend Dr. Watson by drawing a correct conclusion from an array of seemingly disparate and unconnected facts and observations. The method of reasoning used by Sherlock Holmes is abduction. As will be argued in this paper, an advanced Information Society Technology (IST) environment – a mobile computing environment in particular – calls for, or even compels to, the use of abductive reasoning. Abduction is not yet fully understood but it is a better conceptual tool than descriptive adjectives like "interactivity," "mobility" and "ubiquity" that are presently used in IST research. It is better because: First, abduction is a single, rigorous and well-defined unit of analysis, allowing one to analyze and compare diverse phenomena with good scientific accuracy. In the words of Uwe Wirth, research on abduction provides the unique opportunity of approaching interdisciplinarity under a single aspect (1995, p. 405). Second, abduction catches the gist of how we humans reason under uncertainty in a context. Consequently, abduction illuminates the special epistemological circumstances of IST enhanced learning, especially when the learning materials and the environment have been arranged in concord with constructivist educational principles (Patokorpi, 2006a). If it is true that abduction is a central element of everyday thought, and especially significant and ubiquitous in advanced IST environments, it follows that a study of abductive reasoning will help us better understand IST enhanced learning and IST user behaviour as well as provide some insights into Human-Computer Interaction (HCI) design.

The paper at hand will focus on abduction as a central process of everyday human reasoning and its role in HCI, especially its role in IST enhanced learning. Thanks to portable and ubiquitous technology, education increasingly takes place in authentic real-life contexts instead of in the confines of a classroom (Nyíri, 2002; Patokorpi et al., 2006). As a result, the learner is most likely to resort to abductive reasoning more than before. Abduction is of course a central element in traditional education, too, but the new IST lends it a heightened importance. Constructivist pedagogy enters the picture as the currently predominant theory of learning. Constructivist pedagogues have embraced the new IST because it in their opinion naturally supports, or can be made to support, the fundamental constructivist instructional strategies and learning objectives (Tétard and Patokorpi, 2005). Abduction clarifies how learning takes place especially on the level of individuals in and out of cyberspace.

Abduction as an inferential process

The canonical example of abductive reasoning comes from Charles Sanders Peirce:

Rule: All the beans from this bag are white.

Result: These beans are white.
Case: Therefore, these beans are from this bag (CP 2.623).

The inference is not deductively or analytically valid – because the beans could come from somewhere else – but this form of reasoning conveys the manner in which people reason when making discoveries in the sense of coming up with new ideas. Abduction is the only inferential process that gives birth to new ideas, thus expanding our knowledge (CP 2.777; CP 5.171; Wirth, 1995; von Pückler, n.d.). Abduction is a backwards-tracking process of finding or forming hypotheses or theories that might explain a (surprising) fact or an (unexpected) observation. Contrary to a widespread misconception, the fact or facts observed do not necessarily have to be surprising. Abductive reasoning may be used for opening up a new perspective into things even when there is nothing out of the ordinary in them (e.g. humour) (Hoffmann, u/d). Abduction comes to its own in the face of incomplete evidence and high uncertainty that are usually related to very rare or nonrepeatable events and to the realm of the unique in general (Flach, 1996; Yu, 2004; Leake, 1995; Shanahan, 1989).

Abduction has both a psychological (synthetic) and a logical (analytic) dimension closely intertwined (Pückler, u/d; Hoffman, u/d). To borrow Roesler's (n.d.) illuminative example: (P1) a surprising object (fact) is observed which is round, orange coloured and porous. (P2) Oranges are round, orange coloured and porous. If this object were an orange, the object would make sense to us and thus cease being surprising. (C) Ergo: it is plausible that this object is an orange. The premises, containing perceptual judgments, and the conclusion, containing an abductive inference, cannot be sharply separated from one another. However, abductive judgments are more conscious and more controllable than perceptual judgments (CP 5.184; Merrell, n.d.). By producing hypotheses abduction simplifies the complexity of reality, making it intelligible to us. When abduction, as a form of synthetic and qualitative thought, is given a central place in knowing, the hypothetical and provisional nature of human knowledge is underlined (Wirth, 1995; Bertilsson and Christiansen in Peirce, 2001).

Some forms of abductive inference

For the purposes of this study abduction is divided into four basic forms: selective, creative, non-sentential and manipulative (see Magnani, 1998; Magnani et al., 2002). Selective and creative abduction may be further divided in two distinct types (see Figure 1 below). The non-sentential form, in turn, may be divided into five and the manipulative into three subcategories. Finally, the quasi-automatic abduction is here further divided into species-specific and doxatic modes, and all of the five non-sentential modes as well as the man-made manipulative mode may be further divided into two subcategories: creative and selective.

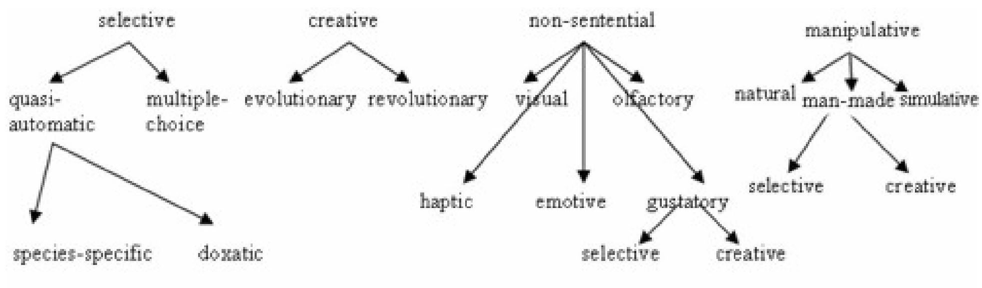

Figure 1. Some forms of abductive inference

Selective abduction, as the name indicates, selects among existing bags (alternative rules, antecedents) the bag that these particular beans (result, clues, consequent) come from. There are two forms of selective abduction: quasi-automatic (Eco's overcoded abduction) and multiple-choice (Eco's undercoded abduction). Abduction may happen almost automatically (quasi-automatically) when there is just one bag (i.e. a singular cause or a general rule or law) to choose from.

Figure 2. Quasi-automatic abduction

Umberto Eco (1983) gives the example that upon seeing a portion of tuna fish on a plate on the table and next to it an opened tin of tuna, one without any conscious effort concludes that the tuna on the plate comes from the tin. In quasi-automatic abduction there is no need to search for a rule as one already exists in the mind. The inference thus proceeds from the result to the case. The principles of proximity, similarity, an objective set, closure, completion and pregnancy could be seen to number among the quasi-automatic abductive processes of human perception (see Wertheimer, 1923). The last-mentioned abductive processes could be said to be common to the human species, whereas some abductions are rather based on culture. Stopping at red lights in traffic is an example of a culturally or conventionally embedded abductive inference. In this case the power of the sign is more due to convention (i.e. to the social institution of the sign) instead of to shared psychological principles or propensities of human perception. The 'traffic light' abduction could be called doxatic and the other one (the gestalt-psychological) could be called species-specific abduction (Bertilsson, 2004).

In a multiple-choice abduction there are two or more rules to choose from. Thus the mind proceeds from the result to the rule (Wirth, 1995).

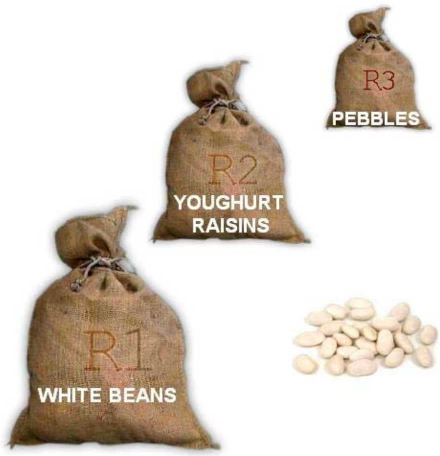

Figure 3. Multiple-choice abduction

An example of a multiple-choice abduction is to be found in Peirce (CP 2.707; quoted in Eco, 1983). The data that Kepler had about the longitudes and latitudes of Mars' revolutions around the sun suggested a finite number of geometrical curves from which to choose. Kepler's hypothesis was that the orbit is elliptical, which he then corroborated against the available evidence.

Creative abduction creates a new bag of beans (i.e. rule) from which the particular beans come from. In other words, the immediately existing (present to the reasoner's mind) bag or bags (contexts) do not fit the result (these beans are white) or there does not exist any general rule, so the reasoner needs to find or create a new one. Generally speaking, by abduction we come up with rules, reasons or laws that explain the case. Insofar as we stick to our prior experience as a ready repertoire of hypotheses, we are not properly engaged in a creative abduction. To infer by abduction that a patient has hepatitis because he or she has jaundice (Josephson and Josephson, 1994, p. 13) is a multiple-choice abduction. If one explains some (in this case the same above-mentioned plus some) symptoms by inferring a new disease (e.g. AIDS when there was no such disease in medical records), it is a case of an evolutionary creative abduction (Reid, 2003; see also Hoffman, 1997).

Figure 4. Evolutionary abduction

The creative revolutionary abduction (Eco's meta-abduction) is a further abduction based on earlier ones. It assesses whether the potential universe created by earlier abductions corresponds to our experiences (Roesler, u/d).

Figure 5. Revolutionary abduction

Galileo's hypothesis of the earth circling the sun, leading to a heliocentric worldview, is an example of revolutionary creative abduction. A revolutionary abduction replaces existing sets of rules by new sets of rules, thus challenging our beliefs in a wholesale manner.

All or any of the five senses may provide the required clues for abductive reasoning (Pierpaolo, n.d.). Especially medicine is known for exploiting all the five senses in the finding of clues (symptoms) when diagnosing an illness. Consequently, there is reason to think that there are many forms of non-sentential abduction, involving vision, touch, smell, taste and feelings. For instance, instead of verbal representations of things and events, we can form pictorial representations. These pictorial representations can be used as vehicles of inferences and explanations, that is, as tools of thought (Thagard and Shelley, 1997). Visual abduction is a form of inference that is based on signs which resemble the thing they represent (i.e. the signs used are icons). This pictorial form of thinking is usually instantaneous, uncontrolled and automatic, thus verging on perception. Visual abduction retrieves from the mind a previously stored piece of (pictorial) knowledge by which a result (these white beans) is referred to a familiar rule (a bag of white beans) (Magnani, 1998). Visual abduction can be either selective or creative. Here is an example of creative visual abduction from Thagard and Shelley (1997). An archaeologist finds two notches on the skullcap of a hominid that probably have led to its death. Is this a case of cannibalism? By picturing the hominid in the jaws of a leopard, the archaeologist can infer (by creative visual abduction) to an alternative explanation. The first explanation that comes to the archaeologist's mind, namely that the hominid has fallen a victim to cannibalism, is a selective visual abduction because the rule is part of the furniture of the reasoner's mind. Creative visual abduction involves the introduction of a new or additional element (diagram or icon; of a leopard in this case) into the reasoning process.

The manipulative abduction could be said to be based on action rather than perception. The reasoner acts non-verbally upon reality, changing the object of observation and then uses the resultant tacit knowledge (which may be embodied in an external or externalised object) as an auxiliary element of the reasoning process. An example of manipulative abduction is the use of auxiliary figures by hand in geometry (Magnani et al., 2002).

Semiotic paradigm of knowledge

In the late 20th century, epistemology has taken an abductive turn. It means among other things that the earlier division into hermeneutic understanding and natural-scientific explanation gives way to abductive educated guessing, that is, to the semiotic paradigm of knowledge (Wirth, 2000). It means also that it is increasingly difficult to keep up strict borders between fields of knowledge as phenomena spill over from one discipline into another (e.g. biophysics). Presumably, the bulk of human knowledge in everyday life is based on hypothetical (abductive) thinking.

Abduction is essentially a matter of finding and following clues (CP 5.262; CP 8.238; Wirth, 1993; Schulz, n.d.; Radford, 2004). However, as Matti Peltonen (1999, pp. 36-37) points out, a clue merely leads the reasoner to something that he or she already knows. Abduction, in contrast to the mere following of clues, aims at eliciting new knowledge. Therefore clues need to be connected to (more or less rough) models or theories, which in turn lays the ground for contrafactual reasoning. The semiotic paradigm (i.e. the science dealing with signs, symbols and clues) of knowledge does not deal with a disciplined regulation of coded knowledge, yet the clues are there for all to see. As Matti Peltonen says (1999, p. 61; with a reference to Clifford Geertz), rather than rediscovering knowledge or things that were forgotten or covered from sight, we constantly create things or knowledge anew by interpretation. By actively interpreting, that is, by giving meanings to things, the observer produces new knowledge. Culture is public and the meanings are recognized by other members of the same culture although they do not always share them. Consequently, the knowledge based on abduction is not esoteric but something that can be communicated to others.

Abduction is first of all a reasoning pattern with strong claims to being democratic. All the relevant knowledge (clues) is in principle "out there," that is, laid out in the open for all to see. Historians (Ginzburgh, 1989; Peltonen, 1999) sometimes talk of this sort of semiotic interpretation and knowledge as low or shallow knowledge, the knowledge of the poor, the oppressed or otherwise marginalized groups in society. Low knowledge should not be understood as sheer, unadulterated observation. Abduction, rather than observation alone, is for instance required to tear down theoretical constructions or social agreements: the Emperor has no clothes. In Hans Christian Andersen's story of the Emperor's new clothes, it is not enough to see (observe) that the Emperor has no clothes because we still believe that he has. A process of abductive reasoning is required: the hypothesis that the Emperor does not have any clothes is a better explanation of the facts of the case. In this way abduction opens up a new perspective. It is material to notice how easy it is to communicate knowledge by abduction; the clues are not hidden but public and the reasoning process is easily repeatable by others.

The clues that are there for all to see are qualitative and unique. They cannot be measured and regulated. This sets the stage for knowledge that is essentially personal. It is personal in the sense that individuals differ in their ability to detect clues, due to individual differences in their prior knowledge and experience as well as logical acumen (Ginzburg, 1989, pp. 8-39; Peltonen, 1999, p. 61). Despite the apparent paradox, knowledge by abduction is simultaneously both personal and democratic.

Art of abductive reasoning

Abduction is best understood as a pattern of temporal reasoning (CP 1.444; CP 2.229; Spina, n.d.; Uslucan, 2004; Bergman, 2002; 2000). The process of abductive reasoning may not come to a conclusion for a very long time but may be suspended until all the relevant or adequate information is in (Josephson and Josephson, 1994; Paavola, 2004b). Abductions stretching over a long period of time are typically complex. An example of a prolonged complex abduction is Darwin's theory of evolution by natural selection. As Thagard and Shelley (1997; see also Roesler, u/d) have pointed out, complex abductions are layered. Layeredness means that each abductive conclusion may become the premise of the next abduction. Thus the higher level hypothesis "John hated Paul" can be used to explain a lower level hypothesis "John killed Paul" (Thagard and Shelley, 1997, p. 417).

In complex abductions the steps of the reasoning process may break out from the confines of a single mind. Reasoning and argumentation may thus be seen not only as internal dialogue or suspended reasoning over time but also as a process involving two or more participants (Wirth, 2000; Pape, n.d.). The following example derives from Richard Whately's Elements of Logic (1st edn. 1826):

> Let us suppose that a group of labourers has dug up a fossil animal with horns on the skull. In other words, the labourers know the minor premiss: "This animal has horns on the skull." Let us further suppose that there is a distant naturalist who knows that all horned animals are ruminants. The naturalist knows the major premiss: "All horned animals are ruminants." As the labourers are ignorant of that all horned animals are ruminants and as the distant naturalist to whom the fossil is described is ignorant of that it has horns, they are both unable to draw the conclusion that it was a ruminant. This is clearly a case in which to reach the conclusion both premisses are required (Whately, 1882, pp. 156-165; elaborated in Patokorpi, 1996, pp. 107-109).

The above example nicely brings out the dialogical nature of thought.

It is possible to trump up hypotheses that meet the formal requirements of abduction but are too far-fetched to be taken seriously. Achinstein's (1970, p. 92; quoted in Paavola, 2004a; CP 2.662; Wirth, 1999) example is that he is happy because he has won the Nobel Prize. There are certainly other reasons for a person to be happy, although winning the Nobel Prize would explain why one is happy. Something else is clearly needed for making abduction a useful mode of inference. What is needed are strategic rules or principles whose job is to guide the reasoner in fitting the hypothesis with the background information and other relevant clues related to the subject matter, the situation and the reasoner's goal. From a strategic viewpoint, it may become necessary to resort to further explanations to show how the hypothesis fits the context in question, and that potential counter-arguments can be warded off (Paavola, 2004a; Paavola, 2004b; CP 5.181; Hoffman, 1997).

Constructivist learning principles

Constructivists maintain that because the learner builds on his or her prior knowledge and beliefs as well as on the knowledge and beliefs of others, learning should be seen in its social, cultural and historical context (Piaget, 1982; Piaget and Inhälder, 1975; Vygotsky, 1969; Leontjev, 1977; Järvinen, 2001; Poikela, 2002; Tynjälä, 1999; Jonassen, 1994). Tétard and Patokorpi (2005) have summarized constructivist instructional principles as follows:

- a larger goal that organizes smaller tasks into a sensible whole
- ownership of the problem so that the learner will be motivated to try to solve it
- the problem should be close to a real world problem
- many possible solutions to a problem
- the learner has the main responsibility for gathering knowledge

- the learning environment should be similar to a real-world environment
- building on the learner's prior knowledge and experience
- room for alternative individual learning strategies
- opportunities for social interaction and cooperation should be provided
- communication with peers and outsiders should be encouraged
- iterative learning process
- guidance should be provided

A quick look at what constructivist educationalists say about IST in education indicates that IST-enhanced learning seems to be in harmony with the constructivist instructional principles. Sotillo (2003) maintains that "New developments in wireless networking and computing will facilitate the implementation of pedagogical practices that are congruent with a constructivist educational philosophy. Such learning practices incorporate higher-order skills like problem-solving, reasoning, and reflection". The students are reckoned to cooperate more, work more intensively and be more motivated than in conventional classroom teaching. IST enhanced teaching is regarded as an efficient equalizer, levelling regional and social inequalities (Puurula, 2002; Hussain et al., 2003; Gruba and Sondergaard, 2001). Langseth (2002) stresses creativity and the fact that the pupils take responsibility for their own work, and, instead of using their logical and linguistic faculties, use a "broader range of intelligences according to their personal preferences" (pp. 124-125). Langseth continues: "The web offers individuality in the sense that you can choose your own pace, your own source of information, and your own method; in a group or alone" (p. 125; Hawkey, 2002; Kurzel et al., 2003). Finally, the students focus more on collaborative work than on the final product (Patokorpi et al., 2006; Tétard and Patokorpi, 2005).

Constructedness of human cognition

Constructivist pedagogues strongly stress the element of active construction in human thinking and perception. A central inferential process behind the constructedness of human experience is abduction. Abduction enables one to posit learning between the rationalist and the empiricist viewpoints, and *a fortiori*, to strike a balance between constructivist, pragmatist and behaviourist learning theories. The existence of several different forms of abductive reasoning may throw light on some disagreements between the constructivists and the proponents of other learning theories, the pragmatists and the behaviourists in particular. Accordingly, the purpose of this section is to illuminate the constructedness of human cognition with the help of the abductive mode of inference.

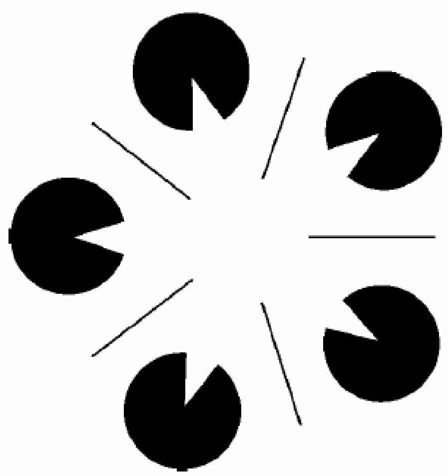

Figure 6. White star illusion

A central piece of criticism levelled at constructivist theories of learning is that they stress deliberation too much. In terms of abductive inferences it means that constructivists exaggerate the role of creative abduction. As learning in the sense of training familiar things and skills seems to belong to quasi-automatic abduction, learning as expansion of knowledge seems to be based on creative abduction and multiple-choice abduction (Wirth, 1993). Fox (2001), who numbers among the recent critics of constructivist learning theories, presents the following figure that illustrates visual illusions:

Figures like this give support to the idea of constructedness of human perception. However, according to Fox (2001), virtually all humans "construct" the figure in the same way, and they do it without any conscious effort or deliberation, and they may at will resist the illusion: "Thus, as well as being impressive examples of the 'constructed' nature of our perceptions, such figures can also be read as examples of the objectivity of human perception, of its deep innate roots and of the way in which we can, up to a point, resist various features of our own initial view" (p. 31). Now, all these three observations made by Fox may be explained by applying different forms of abduction in a layered manner: a selective (quasi-automatic or multiple-choice) abduction followed by a creative evolutionary or revolutionary abduction. Insofar as the reasoner has only one figure present to his or her mind, it is a case of quasi-automatic abduction. Gestalt switches and Necker cubes are good examples of figures in which by training one learns to keep two figures (i.e. two general rules) present to the mind consecutively so that one jumps from one figure to the other more or less at will (Merrell, u/d). If there are two figures (two alternative bags of beans) to choose from, it is a case of multiple-choice abduction. The ability to resist the illusion takes us to the so-called metacognitive level of human mental processes. To make our perceptual and thought processes an object of thought (i.e. reflection in some form) comes to us as naturally as the initial illusionary vision of the figure. Revolutionary abduction is a way of, purposefully, to see things different from what they appear at first. As Wenyan Zhou says, "identifying the abductive object entails comparing one's existing beliefs and evidences revealed in the current situation, becoming aware of the incongruence between them, and discovering the anomalies" (2004, p. 132). Reasoning in its expansive and creative mode is by nature temporal and layered (Roesler, u/d), involving a varying degree of reflection (Leontjev, 1977).

Kivinen and Ristelä (2003, p. 370) criticize the idea of metacognition. They ascribe to constructivists a picture of metacognition as a higher level of consciousness that monitors and evaluates the lower levels. Nevertheless, if metacognition is not seen as two simultaneous levels of cognition but as a temporal process where knowledge-in-action and reflection take turns, the problem vanishes. Some pragmatists seem to have trouble in admitting reflection any clear place in human action. Kivinen and Ristelä's example of an experienced driver and a novice driver misses the point. It is clear that a novice driver makes a worse job of driving than an experienced driver but the main reason for it hardly is because the novice tries to be careful while driving. One of these drivers does not yet know how to drive whereas for the other driving is a routine task. Moreover, reflection and action take turns even when one does something in which one is experienced; reflection merely shows that one is still learning something. Cases of training in which no or very little reflection occur are relatively rare. Much of the conceptual muddle in the case at hand derives from a too elevated picture of reflection. As Bengt Molander (1996) has convincingly argued, reflection allows many forms and degrees. "Just do it!" is a good advice for a timid and ponderous learner learning some very practical skill. On the other hand, it does not validate the conclusion that taking, from time to time, back a step from what one is doing would be a bad thing even in more practical learning tasks. By verbalising, visualising, in a word, externalising learning, it can be made more easily accessible to others as well as to the individual learner himself or herself. Social or collaborative learning is a powerful reason for making learning explicit by reflection and externalisation (Kankkunen, 2004).

IST enhanced learning

As the section on semiotic knowledge above indicates, knowledge by abduction is, by nature, personal, democratic, creative and based on prior knowledge. This is almost exactly the way that many constructivist pedagogues describe learning, as the above section on constructivist learning principles indicates. It is not difficult to become convinced of the resemblances between knowledge by abduction and constructivist learning. Information Society Technology (IST) enhanced learning in general and mobile learning in particular seem to favour the abductive form of reasoning. Abduction could be called the mobile or "pedestrian" form of reasoning *par excellence* because it so well meets the requirements of a mobile learner envisioned by constructivist pedagogues (Nyíri, 2002; Patokorpi et al., 2006).

Abduction is a tool for low knowledge with a tendency to (over)simplification. Therefore, resorting to abductive reasoning has its pitfalls. The construction of a personal meaning goes at times against the objectives of more traditional educational principles, which include the dissemination of uniform knowledge and eradication of false conceptions. Especially due to the immense increase in information, the eradication of erroneous conceptions has become one of the most important and most difficult tasks of today's teachers. In abductive reasoning there is a tendency to resort to guessing before all the facts are in, which leads to over-generalisation and error. Sticking to prior knowledge and experience when the guesswork ends in error may send the reasoner to prolonged attempts at second-guessing the cause of the error and thereby to lengthy error recovery (Carroll, 1990; 1997). A real-life example of this kind of behaviour is when one ignores the manual and proceeds guessing, and when it ends up in error, resorts to some more guessing. Umberto Eco (1983, p. 220) refers to a similar problem when saying that detectives tend uncritically to rely on their abductions whereas scientists meticulously put their hypotheses to test. By modelling learning after scientific discourse, the knowledge creation movement (Bereiter, 1994; Scardamalia and Bereiter, 1994) aims to get the best of both worlds. In epistemic terms, when the learners start with their own questions, the adoption of knowledge produced by others is, as a process, analogous to that of creating knowledge (Bereiter, 1994). The remedy they prescribe to the pitfalls of abductive reasoning is added reflexivity. Added reflexivity translates into increased layeredness of abduction, more attention to logical strategies, more thinking about thinking and intensified dialogue and collaboration between the members of a knowledge community.

According to Hussain et al. (2003), "Edutainment offers children a way to wander through stories, information or games at their own pace and in their own way. They can connect ideas in paths they choose or investigate one particular idea among many" (p. 1077). This is the hypertextual property of the content on the Web. Hypertext is a web of links that sends the reader onto a quest from one piece of text to another. In every act of reading, one piece of text can in principle be connected with any other piece of text. Thereby a text on the Internet loses its book quality (Wirth, 1999). In the words of Spiro et al. (1988):

> The computer is ideally suited, by virtue of the flexibility it can provide, for fostering cognitive flexibility. In particular, multidimensional and nonlinear hypertext systems … have the power to convey ill-structured aspects of knowledge domains and to promote features of cognitive flexibility in ways that traditional learning environments (textbooks, lectures, computer-based drill) could not … (pp. 2-3/20).

So, on the Web the materials (ideas, objects) may be arranged as one pleases. The endless semiosis thus seems to find full vent in the digital media. The user or reader on the Internet may either follow aimlessly the links that he or she comes across or seek clues (meaning) as a detective (Wirth, 1999). We no longer seem to need so much as before a memorized and often visual path to pieces of information or knowledge (e.g. be able to trace by hand a certain passage in Hegel's *oeuvre*). Admittedly, there are technological solutions to tracking paths in a computing environment – bookmarks, track changes and 'go back to the previous page' – but to date, owing to technological limitations, these memory traces are mostly our own personal creations. The point is that it is easier to avoid listening to other points of view (other universes of discourse, world-views) as one may pick up a passage and ignore the rest of the work. As a result, hypertextuality gives more room for our abductive competence and strengthens our personal knowledge structures – sometimes at the expense of not understanding other points of view.

A Sherlock Holmes type of learner calls for laying out the learning materials as in a detective story. In actual fact, often in the new learning media, at least so far, the learning materials have been arranged in a rather strict hermeneutical path of the master. The learner, just like the reader of Internet texts, is supposed to follow the links (clues) so that he or she eventually goes through the same path as the author of the text and links. On the Internet, texts may lose their book quality, but they still need to be read as books, or rather, as detective stories, in order to make sense. Texts, in general, need to be inherently coherent to enable us to interpret them instead of just utilizing them (Wirth, 1999). We still have to see the text as a contribution coming from another conscious mind because human thought is by nature dialogic. This comes close to the idea of a hermeneutic cycle. In the footsteps of Karl-Otto Apel (1973), abduction is here interpreted as an inherent part of the hermeneutic cycle. At the very least, knowledge building, hermeneutics and abductive reasoning could be seen as complimentary perspectives to the temporal and dialogical process of knowledge creation and renewal in a shared culture.

Along with the new media (TV, video, PC games, virtual reality etc.) images have become a more pivotal vehicle of meaning and communication in all walks of life. Pictorial knowledge has always had its defenders, although they seem to be in the minority. Peirce is a case in point: "For Peirce, the human mind is not a calculating engine, but it is a mind which draws figures," says Leila Haaparanta (2001; CP 3.363). Pictures often are more concrete and simpler than meanings mediated by verbal language but they are often also clearer and easier to understand. In the words of Kristóf Nyíri: "Due mainly to advances in cognitive science, philosophers today increasingly recognize that we do indeed have the capacity of thinking *directly* with images, without verbal mediation. And, due mainly to advances in computer software, pictures are today becoming a convenient vehicle for communicating ideas" (Nyíri, 2002, p. 3/4). Especially moving images are important because they have the capacity to be self-interpreting. Pictorial knowledge is essentially interdisciplinary and less hierarchical than verbal knowledge. However, language and communication have their anthropological basis in all of the five senses, not just in vision. With this cognitive species-specific makeup in mind, Kristóf Nyíri (2002) argues for the natural suitability of modern ubiquitous and multimodal IST to human communication and learning. Today, learning takes increasingly place not in the school but out there in the world, and it is supported by the same tools with which most communication and work is done, namely the ISTs. If and when mobile learning gets under way within and outside the educational system, abduction seems like a good candidate for an interdisciplinary conceptual tool for both educational and technological research.

Conclusion

Abduction is a form of expansive and qualitative thought that makes reality intelligible to us. The paper has introduced well over ten forms of abductive inference, with examples showing how this type of reasoning works. Abduction is the cornerstone of the semiotic paradigm of knowledge. This type of knowledge is low knowledge: creative, personal, democratic, easy to understand and easily communicable to others (Patokorpi, 2006). The main argument put forward in this paper is that abduction illuminates the special epistemological circumstances of IST enhanced learning, especially when the learning materials and the environment have been arranged in concord with constructivist educational principles. If it is true that abduction is a central element of everyday thought, and especially significant and ubiquitous in advanced IST environments, it follows that a study of abductive reasoning will help us better understand IST enhanced learning and IST user behaviour as well as give us some valuable hints to the design of human-computer interaction in general.

Constructivist pedagogues strongly stress the element of active construction in human thinking and perception. A central inferential process behind the constructedness of human experience is abduction. By clarifying the role of abduction in learning should enable one to strike a balance between constructivist and pragmatist learning theories. Accordingly, some forms of abductive reasoning have been used in this paper to throw light on some central disagreements between the constructivists and the pragmatists.

Today, learning takes increasingly place not in the school but outside the classroom, and it is supported by the same tools with which most communication and work is done, namely the ISTs. If and when mobile learning gets under way within and outside the educational system, abduction seems like a good candidate for an interdisciplinary conceptual tool for both educational and technological research.

In this paper, an abductive learning or thinking style is connected to a pedagogical approach. The analysis of an abductive reasoning style utilized by users of IST could be used to develop new educational strategies. Constructivist pedagogy could give some directions for building educational programmes around IST and this particular form of reasoning. The developing of such educational programme and practical approach using the presented connections between computer-based information systems, human reasoning, and the learning process will be left to others or to future work. As has been argued in Patokorpi (2006b; Patokorpi et al., 2006), there are some mismatches between the available technology and the constructivist learning theory and practice. Especially the personalisation technologies are still too immature to provide good support for constructivistically oriented IST enhanced learning. Abduction also requires backing up by deduction (to trace the consequences of hypotheses) and induction (to test hypotheses) to make the hypotheses (guesses) not just plausible but accurate as well. The cyberspace can in principle be made to support also deductive and inductive reasoning. New research is needed to clarify how particular technologies and applications, applied by different pedagogical approaches to various learning environments support or fail to support an abductive learning style.

Finally, the recent systemically oriented research and design of IST enhanced learning, particularly under the label of computer supported collaborative learning, is all well and good as it often gives a sophisticated picture of the process of learning and of the dialogical unity of knowledge and action. However, there is need for research which analyses the learning process more from the concrete viewpoint of individuals – without covering from sight other minds, action and artefacts. Abduction could have an important role in this kind of research and instructional design.

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Asan, A. (2007). Concept Mapping in Science Class: A Case Study of fifth grade students. *Educational Technology & Society*, 10 (1), 186-195.

Concept Mapping in Science Class: A Case Study of fifth grade students

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ABSTRACT

The purpose of this research project was to determine the effects of incorporating concept mapping on the achievement of fifth grade students in science class. The study was conducted with twenty-three students at Ata Elementary School, Trabzon, Turkey. The students were tested with teacher-constructed pre- and post tests containing 20 multiple-choice questions. The pupils in the experimental and control groups were exposed to the same teaching techniques covering a unit on heat and temperature. They were given the same pretest after the initial lessons. However, after the pretest, the control group was given a traditional oral review of the material and the experimental group was exposed to the review by the use of Inspiration, which is computer based concept mapping tool. After these reviews, the students on both groups were given the posttest. Test scores were analyzed for any statistically significantly difference in the scores on the test. The results from present study indicate that concept mapping has a noticeable impact on student achievement in science classes.

Keywords

Computer based concept mapping, Concept mapping, Inspiration, Science education

Introduction

Concept maps are spatial representations of concepts and their interrelationships that are intended to represent the knowledge structures that humans store in their minds (Jonassen, Beissner, & Yacci, 1993). Joseph D. Novak of Cornell University is considered to be the one who, in the 1960s, started the systematic use of concept mapping for learning (Novak, 1993). His work was based on two important ideas in Ausubel's (1968) assimilation theory of cognitive learning:

- Most new learning occurs through derivative and correlative subsumption of new concept meanings under existing concept or propositional frameworks. Learning that is meaningful involves reorganization of existing beliefs or integration of new information with existing information.
- Cognitive structure is organized hierarchically, with new concepts or concept meanings being subsumed under broader, more inclusive concepts.

The theoretical framework that supports the use of concept mapping is consistent with constructivist epistemology and cognitive psychology. Constructivism is a major influence in current science education.

Concept mapping is a method to visualize the structure of knowledge. Since the knowledge expressed in the maps is mostly semantic, concept maps are sometimes called semantic networks. Often it is claimed that concept mapping bears a similarity to the structure of long-term memory. Instead of describing all concepts and their relations in text, one may choose to draw a map indicating concepts and relations in a graph or network. Visual representation has several advantages. Visual symbols are quickly and easily recognized, and this can be demonstrated by considering the large amount of logos, maps, arrows, road signs, and icons that most of us can recall with little effort. Visual representation also allows the development of a holistic understanding that words alone cannot convey, because the graphical form allows representations of parts and whole in a way that is not available in sequential structure of text (Lawson, 1994).

The traditional way of constructing concept maps uses paper and pencil. With the rapid development of Information and Communication Technologies (ICT), a number of computer-assisted concept mapping systems have been proposed (Fisher, 1990). Concept mapping tools are computer-based, visualizing tools for developing representations of semantic networks in memory. Essential for concept mapping tools is their ability to elicit the right level of complexity and detail in the student's exploration (Kommers, 1995). Programs such as SemNet, Learning Tool, Inspriation, Mind Mapper, and many others, enable learners to interrelate the ideas that they are studying in multidimensional networks of concepts, to label the relationships between those concepts, and to describe the nature of the relationships between all of the ideas in the network.

In science education, concept mapping has been widely recommended and used in a variety of ways. It has been used to help teachers and students to build an organized knowledge base in a given discipline (Pankratius, 1990) or on a given topic (Kopec, Wood & Brody, 1990). It has been used to facilitate middle level students' (sixth, seventh, and eighth grade) learning of science content (Guastello et al., 2000; Hawk, 1986; Ritchie & Volkl, 2000; Simmons et al., 1988; Willerman & Mac Harg, 1991; Sungur et al., 2001; Duru and Gurdal 2002). Findings from these studies indicate that the concept mapping is an effective tool for aiding student comprehension and retention of science material. Additionally, students using concept maps scored higher on posttests than students receiving more traditional types of instruction. Furthermore, concept mapping has been used to assess what the learner knows (Wandersee, 1987), and to reveal unique thought processes (Cohen, 1987). The development of science curriculum (Starr & Krajcik, 1990) and the evaluation of instructional activities for promoting conceptual understanding (Kinnear, Gleeson & Comerford, 1985) are some other applications of concept mapping. In addition, concept mapping has been used to promote positive self- concepts, positive attitudes toward science (Novak & Gowin, 1984) and increased responsibility for learning (Gurley, 1982).

Also the benefits of concept mapping tools across several content areas (social studies, mathematics, Spanish as a second language, vocabulary, reading, and writing), multiple grade levels (first through senior high school), and different student populations (regular education students and students with learning disabilities) have been verified in the following several experimental studies.

Concept mapping tools allows students to customize maps in ways that are not possible using paper-and-pencil. Anderson-Inman and Zeith (1993) compare the use of the concept mapping program Inspiration with the paper-and-pencil approach and found that using this program encourages revisions to the concept map because deletions, additions, and changes are accomplished quickly and easily. Especially young students who still struggle with hand-writing skills benefit greatly from concept mapping tools.

Four studies (Alvermann & Boothby, 1983; Alvermann & Boothby, 1986; Armbruster et al., 1991; Griffin et al., 1995) in the area of social studies used concept mapping tool to help students organize information from expository texts and comprehend content area reading. All four studies were conducted with either fourth- or fifth-grade students. Findings from these studies concluded that concept mapping tool helped students select, organize, and recall relevant information, as measured by posttests. Students were also able to transfer thinking and learning skills to novel situations and content.

One experimental study (Braselton & Decker, 1994) with sixth-grade mathematics students found concept mapping tools to be advantageous in the improvement of students' problem-solving skills. Another study (DeWispelaere & Kossack, 1996) in a junior high and high school Spanish as a second language class found that concept mapping tool improved students' higher order thinking skills as measured by performance on chapter quizzes, tests, and student projects.

Three studies (Bos & Anders, 1992; Ritchie & Volkl, 2000; Griffin et al., 1995) examined the effects of graphic organizers on retention and recall. Overall findings of the three studies indicated that graphic organizers are a helpful method for improving student retention and recall of information for both elementary and junior high students with learning disabilities, as well as upper elementary students (fifth and sixth grade). Follow-up tests at various intervals following instruction found that students retained information they learned via graphic organizers. In one study, graphic organizers were also found to help students transfer retention and recall skills to new situations (Griffin et al., 1995).

The above-referred research increasingly supports the idea that the use of concept mapping tools can extend and enrich students' learning in science and technology in important and unique ways. Starting from 2005-2006 academic years, the total length of the elementary education combined with the high school education has increased from eleven to twelve years in Turkey. This was done to comply with the education chapter of EU membership negotiation process that was started on November 3, 2005. In this new process, The Ministry of National Education of Turkey is obligating the schools to apply the newly developed science and technology curriculum. According to this new curriculum every student must develop a thorough knowledge of basic science concepts, which they can apply in a wide range of situations. The students must also develop the broad-based skills that are so important for effective functioning in the world of work: they must learn to identify and analyze problems and to explore and test solutions in a wide variety of contexts. This firm conceptual base and these essential skills are at the heart of the newly developed science and technology curriculum and must be the focus of teaching and learning in the classroom.

In the light of preceding introduction on the concept mapping, we can conclude that, in the world of science, concepts are very inter-related, and many concepts are built on many others, and therefore concept mapping would be very useful in the science classroom as a learning tool. It is well known that concept mapping tools has been widely recommended and used in a variety of ways in science education in advance countries such as UK, USA, or Japan. But it is still new method and not adapted by science teachers in Turkey. The reason could be the problems in developing Novak's style concept maps in Turkish caused by linguistic differences between Turkish and English. But adapting concept maps to Turkish is possible (Bagci Kilic, 2003). This research paper aimed to investigate the effects of incorporating concept mapping on achievement and attitudes of fifth grade students in science classes. It is expected that the findings of this research will encourage science teachers to incorporate concept maps into their teaching and will help them to adopt new techniques to evaluate concept maps. The findings of this research will assist science teachers with developing new skills to apply the newly developed science and technology curriculum in Turkey.

Hypothesis

It is hypothesized that there will be a statistically significant difference between 5th grade students who are exposed to concept mapping by using Inspiration program in addition to regular teaching practices as opposed to those who are not exposed to concept mapping tool with respect to academic achievement. It is also hypothesized that concept mapping as an instructional tool has a positive effect on students' attitudes.

Methodology

Research Design

The point of this research project was to determine the effects of using Inspiration concept mapping program on student achievement of fifth grade students. A Nonequivalent Control Group Design was used. The independent variable was the incorporation of Inspiration concept mapping program into the instruction. The dependent variable of the experiment was the level of student achievement on the posttest; that was determined by a teacher-made test.

Sample

Participants in this study were 23 fifth-grade students enrolled in science classes during the spring of 2005 in Ata Elementary School in Trabzon, TURKEY. Of the students who participated, 51% were female and 49% were male.

Instrumentation

Three instruments were used in this study: 1) Multiple Choice Test, 2) Concept Map Scoring Rubric, and 3) Student Interview Questions.

1) Multiple Choice Test: Comprehension of concepts in Heat and Temperature covered by the unit was measured by a teacher-constructed paper and pencil test. In designing multiple-choice test, the teacher, in consultation with the researcher, first reviewed all pertinent information: instructional objectives, teacher class notes, lesson plans, and study guides given to the students. Based on this information and the teacher's knowledge of what had actually transpired in class, a table of specifications was constructed (Linn and Gronlund, 1995). Using this table, the teacher wrote all test items related to a list of concepts to be used by students in concept map preparation process. The test was consisted of 20 multiple-choice questions. The questions were worth five points each and the tests were rated on a 100-point scale. Reliability and validity were established prior to the start of the study by the following procedures:

pre- and posttest was provided to five teachers who have at least five years of teaching experience in science. These teachers evaluated the multiple-choice test to make sure that the questions are aligned with the course content and level. The science teachers also evaluated the instruments for readability. The questions on the pre-test and post-test were similar.

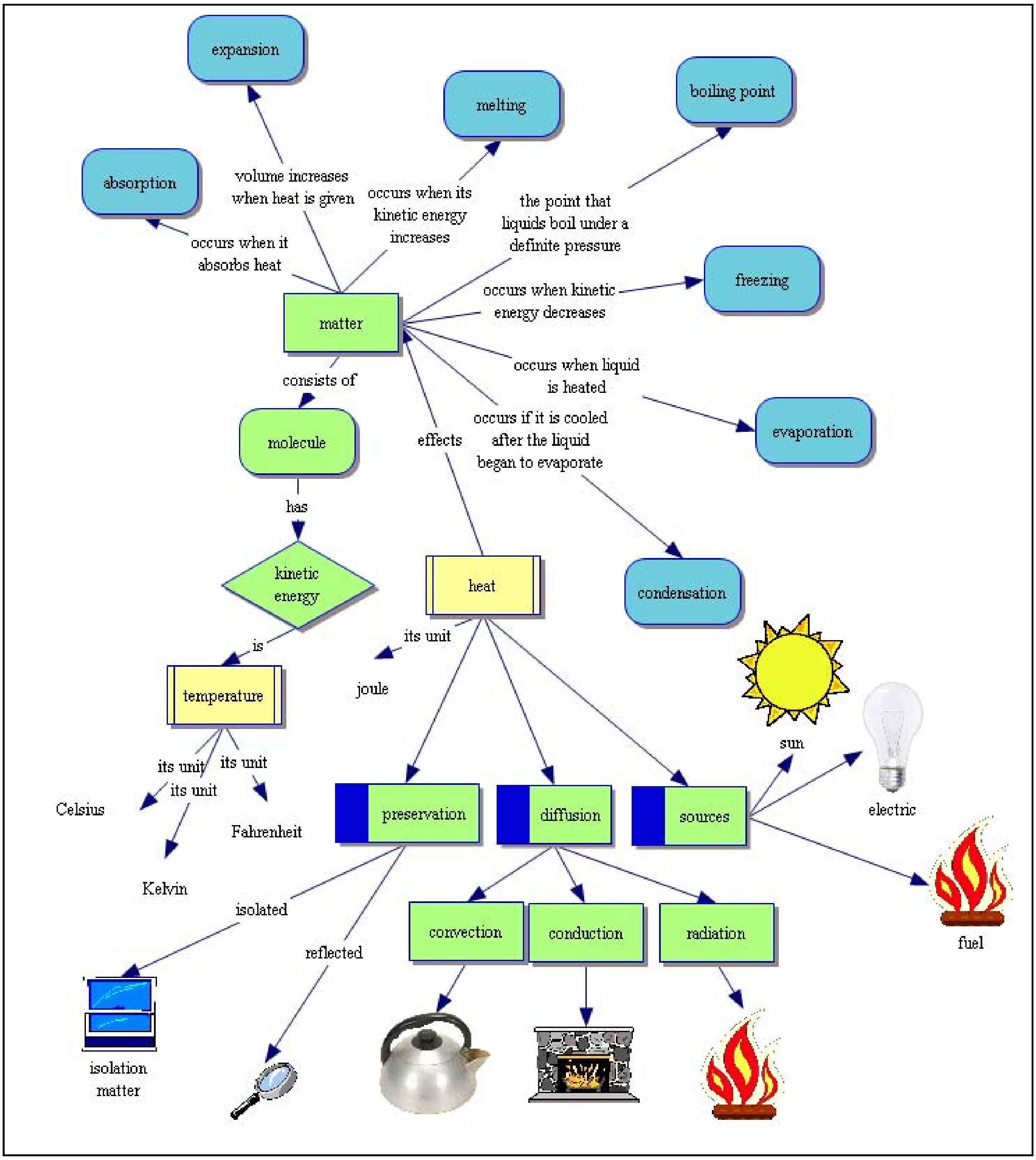

Figure 1. Concept map representing a heat and temperature unit

2) Concept Map Scoring Rubric: Concurrent with the development of the multiple-choice items, the list of concepts developed for students to use on their concept maps. 22 concepts were identified. For each concept, a positive score

(+1) was given if the stem concept was linked accurately to the correct answer, and a score (-1) recorded if a linking error was made. If one of the concepts were missing from the map, a score 0 was indicated. To obtain a score +1, students had to have all essential stem concepts linked to answer concepts somewhere on their maps.

3) Student Interview Question: Affective data were collected by interviewing all students in experimental group approximately 3 weeks after the end of the study. One open-ended question was used to assess the students' reactions to concept mapping process. Students were asked to describe their feelings while drawing concept maps in science class. Negative and positive comments were analyzed.

Procedures

This study was conducted over a five-day period during classes that meet for ninety minutes each day. A total of 23 students were randomly divided into two groups: the experimental group and the control group. Both groups were covered the same material as outlined in the class textbook, regarding the chapter that covers heat and temperature. The teacher introduced the chapter and the objectives for learning to the control group; the rest of the week proceeded as follows: days 1 through 3 included lecture, overhead transparencies, and a unit worksheet. Day 4 included the 60-minute pre-test followed by an oral review of the week's material. Oral review also included question-answer session and discussion of the important concepts identified by students. In day 5 students completed the 60-minute posttest. In the experimental group students were exposed to a short lesson in computer lab on concept mapping and the proper procedures for creating concept maps by using Inspiration program. Shortly thereafter the students were placed into groups of three and given a short activity in the computer lab to determine if they understand the process of concept mapping. Once this was complete the teacher introduced the chapter and the objectives for learning to the experimental group; the rest of the week proceeded as follows: days 1 through 3 included lecture, overhead transparencies, and a unit worksheet. Day 4 included the 60-minutes pre-test. Concept mapping process began with a discussion session. A short list of 22 concepts was produced during class discussion. After that, the students worked individually to draw maps of these concepts on computer screen by using Inspiration program. Figure 1 shows an example of concept maps that is generated by one of the students in the experimental group. These maps were graded for purposes of regular class assessment based on the number of correct linkage between two terms or concepts via a directional arrow on which an appropriate label had been placed. In day 5, students completed the 60-minutes posttest. All activities and materials were the same for each group with the exception of the use of Inspiration concept mapping tool with the experimental group.

Findings

Pre-posttest results

As it is seen from Table 1, pre and posttest results for control group students indicate that there was no statistically significant difference between two groups at alpha level of 0.05.

Table 1. Pre and Posttest Results of Control Group

Control Group	Mean	N	Std. Deviation	Std. Error Mean	t	Sig.(2-tailed)
PRETEST	65,0000	10	6,66667	2,10819	-,667	,522
POSTTEST	67,0000	10	8,88194	2,80872		

$p<0.05$

Table 2. Pre and Posttest Results of Experimental Group

Experimental Group	Mean	N	Std. Deviation	Std. Error Mean	t	Sig. (2-tailed)
PRETEST	65,0000	13	8,66025	2,40192	-5,598	,000
POSTTEST	83,0769	13	8,54850	2,37093		

$p<0.05$

Table 2 illustrates statistical analysis of pre and posttest results for experimental group students. At the end of the study, experimental group performed in a statistically significant manner at alpha level of 0.05. The experimental group achieved a higher mean score in posttest. The t test results indicate that the improvement in scores from the pretest to the posttest was significant (t = -5,598 p<0.05).

Students' Concept Map Scores

13 concept maps were examined and student scores were recorded by using scoring rubric. If one or more of the concepts were missing from the map, a score of 0 was given. To obtain a score other than 0 in this category, students had to have all essential stem and answer concepts somewhere on their maps. A positive score (+1) was given if the stem concept was linked accurately to the correct answer, and a negative score (-1) recorded if a linking error was made. The results of scoring for the maps of thirteen students are reported in Table 3.

Table 3. Students' Concept Map Scores

Concepts	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12	S13
Heat	+1	-1	+1	+1	+1	+1	+1	+1	-1	+1	+1	-1	+1
Temperature	+1	+1	-1	+1	+1	+1	+1	+1	+1	-1	+1	+1	-1
Unit of heat	+1	+1	+1	+1	+1	+1	+1	+1	+1	+1	+1	+1	+1
Unit of Temperature	+1	+1	+1	+1	+1	+1	+1	+1	+1	+1	+1	+1	+1
Kinetic Energy	+1	-1	+1	+1	+1	-1	-1	+1	-1	+1	+1	+1	+1
Heat Energy	+1	+1	-1	+1	+1	+1	+1	+1	+1	-1	+1	-1	+1
Electrical Energy	+1	+1	+1	-1	+1	+1	+1	+1	+1	+1	+1	+1	+1
Heat Transfer	+1	0	+1	+1	-1	+1	+1	+1	+1	+1	0	+1	+1
Convection	+1	0	+1	+1	0	+1	-1	+1	+1	+1	-1	+1	+1
Conduction	+1	+1	+1	+1	+1	+1	0	+1	+1	+1	+1	+1	+1
Radiation	+1	-1	+1	+1	-1	+1	0	+1	+1	0	+1	+1	+1
Reflection	+1	+1	+1	0	0	+1	+1	0	+1	+1	+1	0	+1
Insulation	+1	+1	+1	+1	+1	+1	+1	+1	+1	+1	+1	+1	+1
Phase Changing	+1	+1	+1	+1	0	+1	+1	+1	+1	+1	0	+1	+1
Boiling Point	0	+1	+1	+1	+1	+1	+1	+1	+1	+1	+1	+1	-1
Evaporation	+1	+1	+1	+1	+1	+1	0	+1	+1	+1	+1	0	+1
Expansion	+1	+1	-1	+1	+1	+1	+1	+1	+1	+1	0	+1	+1
Condensation	+1	+1	+1	-1	+1	+1	+1	+1	-1	+1	+1	+1	-1
Freezing	+1	+1	+1	+1	0	+1	+1	+1	0	+1	+1	+1	+1
Cooling	+1	+1	+1	+1	+1	+1	-1	+1	+1	+1	+1	+1	+1
Melting	+1	+1	+1	+1	+1	0	+1	+1	0	+1	+1	+1	0
Fuel	+1	+1	+1	0	+1	0	+1	+1	+1	+1	+1	+1	+1
Total Score	20	14	16	16	14	18	13	21	14	17	17	16	15
%	90	63	72	72	63	81	59	95	63	77	77	72	68
Average							**73**						

+1: Correct -1: Incorrect 0: Not on the Map

S1: Student 1

Relationship between Concept Map Scores and Multiple Choice Scores

On unit test, two subgroups of multiple choice items were identified: map related, or those items built from several concepts on the concept list; and other or those items that could not be linked as completely to the concept list. 8 map-related multiple choice test items were identified. Scoring rubric was used for these eight items. Students' concept map scores were correlated with the scores identified as map-related (multiple choice questions which could also be answered on the maps). As it is seen from Table 4 the correlations between map scores and the scores on the map-related multiple-choice items on the unit test varied from .4 to .7. The correlations were generally high. The strength of the relationship between concept map scores and multiple-choice scores provides strong evidence for the content validity of the concept map scores. These results indicate that students were performing quite similarly on the concept map items and multiple choice items designed to measure similar content. It can be concluded that the concept map scores were indicators of students' knowledge of content, which had been emphasized during instruction.

Table 4. Comparison of answers of related multiple-choice items with concept map answers

	Map-Related Concepts																
	1		2		3		4		5		6		7		8		**Pearson r**
	MC	CM	MC	CM	MC	CM	MC	CM	MC	CM	MC	CM	MC	CM	MC	CM	
S1	+1	+1	+1	+1	+1	+1	+1	+1	+1	-1	-1	-1	+1	+1	+1	+1	0,6
S2	+1	+1	-1	-1	-1	-1	-1	-1	-1	+1	-1	-1	+1	+1	+1	-1	0,4
S3	+1	+1	-1	+1	+1	+1	+1	+1	+1	+1	-1	-1	+1	0	+1	+1	0,6
S4	+1	+1	+1	+1	-1	-1	-1	-1	+1	+1	+1	+1	-1	+1	+1	+1	0,7
S5	+1	+1	+1	+1	-1	-1	-1	+1	+1	+1	+1	0	+1	+1	+1	+1	0,6
S6	+1	+1	+1	+1	+1	+1	+1	+1	-1	-1	+1	+1	+1	+1	+1	+1	1
S7	+1	+1	+1	0	-1	+1	-1	+1	-1	-1	+1	+1	+1	+1	+1	+1	0,4
S8	+1	+1	+1	+1	+1	0	-1	-1	+1	-1	+1	+1	+1	0	+1	+1	0,6
S9	+1	+1	+1	-1	+1	+1	-1	-1	-1	-1	+1	0	+1	+1	+1	+1	0,7
S10	-1	-1	-1	+1	+1	+1	+1	+1	+1	+1	+1	0	+1	0	+1	+1	0,6
S11	+1	+1	+1	0	-1	-1	+1	0	+1	0	+1	+1	+1	+1	-1	+1	0,6
S12	+1	+1	+1	-1	+1	+1	+1	-1	+1	+1	-1	0	-1	-1	+1	+1	0,4
S13	+1	+1	-1	-1	-1	-1	+1	+1	+1	+1	-1	0	-1	+1	+1	+1	0,7

MC: Multiple Choice Test CM: Concept Map

Students' Reactions to Concept Mapping

Table.5. Summary of student reactions to concept mapping in science class (n =13)

Student Responses	n	%
Helpful	7	54
Fun	8	61
Easy	8	61
Difficult	4	30
Difficult but helpful	1	7
Boring	1	7

Concept mapping was generally perceived in a positive light by students in the study. Students generally (%54) found the concept maps very helpful for organizing ideas. According to the students, using Inspiration helped them to understand the material. For example S6 indicated that using Inspiration gave him opportunity to develop better understanding about the topic and seeing how concepts are and/or connected. S4 indicated that as a result of making links between concepts, they began to really understand and search out interrelationships between concepts that created new meaning for them. S11 described that finding the connections was a way of double-checking his understanding of new material. %61 of students indicated that working with Inspiration was fun and enjoyable experience. According to the students, the ease and flexibility of the Inspiration made learning an enjoyable. As S9 reported "I enjoy trying to get each concept and make them relate". Students also enjoyed creating a visual representation of concepts. A large percentage of the participants (%61) expressed that learning to use Inspiration and linking the related concepts was an easy process. Only one student expressed difficulty in developing maps. S2 indicated that mapping as a learning strategy was too demanding and took up too much time. Also S12 reported that mapping was difficult but was helpful at the same time.

Conclusion

This study provides an additional insight into prior research conducted in concept mapping and its effect on learning. The findings reveal that concept mapping has a noticeable impact on student achievement and student attitudes.

Further, although results of the learning outcomes are encouraging, the results are by no means conclusive, because of the weakness of the metrics for attitude assessment, and longitudinal studies that explore student attitudes toward the use of concept maps will be helpful to understand students' developing conceptual knowledge.

This study has implications especially for science teachers in Turkey where science curriculum is being redeveloped and mainly based on concept acquisition. Using concept mapping tools in science classes will help students to develop better understanding of important concepts. Students in this study demonstrated that concept maps helped them to understand the learning processes of developing interrelationships, creating meaning schemes and constructing knowledge bases. Once they were able to learn in this fashion and explain their own learning, they were much better prepared to function in future science courses. The biggest challenge for science teachers is changing teaching approaches to incorporate what we know about effective and meaningful learning. Using concept maps necessitates that science teachers have a good understanding of constructivist learning and the ways in which maps represent students' thinking. Finally, to use mapping science teachers need to be willing to foster an approach to learning as meaning construction. This means that the focus of courses shifts from teaching and presenting information to learning and creating meaning.

This study was conducted with limited number of students. Concept mapping has been approved to be an effective learning strategy in science education in advance countries. Such studies that will have been carried in developing countries should include larger sample sizes in order to determine the most efficient means of using concept mapping tools for maximum benefit and identify the possible effects of gender differences and cultural bias.

Concept mapping tools offer another means to create the necessary "minds-on" environment that distinguishes coherent science instruction from a series of isolated activities. Concept mapping requires the learner to make an effort to understand concept meanings, organize concepts hierarchically and form meaningful relationships between concepts to form a coherent, integrated network of the material learned. Engaging the learner in such constructive and transformative cognitive operations during learning enhances memory and recall for the material learned.

According to research, students better remember information when it's represented and learned both visually and verbally. Concept mapping tools are based on proven visual learning methodologies that help students think, learn and achieve. Visual learning is absorbing information from illustrations, photos, diagrams, graphs, symbols, icons and other visual models. By representing information spatially and with images, students are able to focus in meaning and recognize and group similar ideas easily. The use of concept mapping as a learning tool should therefore be more widely encouraged.

In summary, this study indicates that concept maps can effectively promote learning of students and thus, can be added to the teaching strategies of science teachers. The maps contribute to student success, foster a long-term change in thinking, and contribute to changing students' learning strategies. The maps support both constructivist teaching and learning approaches and may have wider applicability to the work world as well.

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Students' attitudes towards animated demonstrations as computer learning tools

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ABSTRACT

Animated demonstrations are increasingly used for presenting the functionality of various computer applications. Nevertheless, our understanding of whether and how students integrate this technology into their learning strategies remains limited. Although, several studies have examined animated demonstrations' learning efficiency, this study aims at investigating users' initial attitudes towards animated demonstrations as computer learning tools. Attitudes about knowledge sources play a determinative role for their acceptance. Quantitative and qualitative information was collected from forty-six interviews with students who used animated demonstrations for the first time. Students appraised animated demonstrations with regard to their authentic representation of task sequences, arguing that comprehension of the demonstrations did not entail intensive metacognitive burdens. On the contrary, students claimed that animated demonstrations had browsing inefficiencies and sometimes failed to satisfy individual learning needs. Interview transcripts revealed that students' attitudes were influenced by several factors, such as the nature of the computer application to be learnt, students' prior knowledge of that application, their prior learning practices, narrator's characteristics, simulated practice options and the procedural segmentation of the presentation. Results of the study can be exploited to enhance the design of educational applications that incorporate animated demonstrations.

Keywords

Animated demonstrations, Computer learning, Students' attitudes, Exploratory study

Introduction

The ceaseless development and evolution of computer applications has dramatically increased the time and effort required for learning to use computers. Users of a growing number of everyday computer activities face labyrinths of features and services. They often familiarize themselves with only a small portion of the application's functionality and in most cases, fail to exploit the functionality efficiently and effectively (Leutner, 2000). Ironically, users' limited knowledge is likely to become insufficient or out of date in a very short period of time, as a result of the frequent software upgrades (Phelps, Hase & Elis, 2005).

The incidental nature of computer learning needs has forced users to use informal knowledge sources, such as hands-on experience and their social environment (Rieman, 1996; Phelps, Hase & Elis, 2005). Studies have revealed that users explore an application's interface and functionality immediately after installation (Carroll, 1990), making limited use of the help system or the accompanying documentation (Rieman, 1996). When challenged to overcome technical difficulties, they tend to seek for help from more experienced family members, friends or colleagues, because of their ability to provide immediate and concise support (Winter, Chudoba & Gutek, 1997). Even though the need for systematic support of users is widely accepted (Bannert & Reimann, 2000), there appears to be an absence of adequate knowledge sources that meet these learning needs.

Today, promising efforts to enhance computer learning are concentrated on educational applications that incorporate animated demonstrations. Animated demonstrations (ADs) reproduce a screen-captured usage scenario of a software application with verbal explanations. Benefits of using animations to present the functionality of software applications were documented as early as the 1980s (Shneiderman, 1983; Rieber, 1990). ADs' primary instructional value is the authentic and graphical representation of the mechanisms by which users can perform various tasks and achieve particular results (Palmiter, 1993). ADs can help users identify more easily the required actions and the corresponding interface objects associated with target activities, eliminating the "referential step" (Just & Carpenter, 1987) required for the comprehension of textual instructions (Palmiter & Elkerton, 1991). ADs promote the continuous development of a relationship between the user's actions and the system's responses, while textual representations require the user to imagine the described interactions (Palmiter & Elkerton, 1991; Harrison, 1995).

While many studies have noted the positive results of using ADs, other studies yielded contradictory results. For example, it has been asserted that ADs are not a panacea and often not used (Pane, Corbett & John, 1996; Tversky, Morrison & Betrancourt, 2002) and they also may lead to mimicry (Atlas, Cornett, Lane & Napier, 1997). Furthermore, researchers have claimed that ADs do not foster the long-term maintenance of knowledge and its transferability to new contexts (Palmiter & Elkerton, 1991), may distract users from concentrating on key issues (Weiss, Knowlton & Morrison, 2002) and have fundamental usability flaws (Carroll & Mazur, 1986).

Despite the controversial conclusions, most users appear to be very willing to use ADs (Payne, Chesworth & Hill, 1992; Harrison, 1995). This is also confirmed by the recent growth of ADs' use in help systems, educational applications, software presentations, and even gaming instructions (Shneiderman & Plaisant, 2005). Nevertheless, our understanding of ADs' advances in learning efficiency and the criteria for accepting or rejecting them remains limited. In this study we investigate users' attitudes towards ADs as computer learning tools.

Research goals

Contrary to prior studies that focused mainly on the examination of ADs' learning efficiency, we aimed at detecting users' attitudes towards ADs after encountering them for the first time. According to the Theory of Reasoned Action (Ajzen & Fishbein, 1980), attitudes towards objects and behaviors constitute an important determinant of subsequent actual behavior. Similarly, the Technology Acceptance Model (Davis, Bagozzi & Warshaw 1989) postulates that cognitive beliefs about using an object, such as perceived usefulness and perceived ease-of-use, affect attitudes towards using that object, the intention to use it, and ultimately, the use of that object.

Users' attitudes towards computer learning sources are even more significant nowadays. The increased need for continuous development of computer skills has prompted an intense pursuit of suitable knowledge sources. Students tend to assess each knowledge source hastily and relative to the other sources available for their specific learning needs. In the end, their learning strategies depend more on multiple qualities of sources and less on the longitudinal learning efficiency that could be achieved in an ideal learning environment. Consequently, attitudes towards knowledge sources are a significant indicator of users' future strategies for their exploitation. However, attitudes are not the only factor in determining behavior; inconsistencies between attitudes and behavior are to be expected.

Although several studies have delved into ADs' learning efficiency and drawn inferences about students' attitudes (e.g. Palmiter, 1993), this study was focused on students' elaborations of their first experience with ADs. The study sought to:

- Identify students' initial attitudes toward ADs' learning efficiency and appropriateness for computer learning,
- Recognize ADs' features and contexts of use that may influence those attitudes,
- Associate users' beliefs with personal characteristics (e.g., sex, prior computer knowledge),
- Suggest implications for enhancing the design of educational applications that incorporate ADs.

Research methodology

Individual interviews were conducted with forty-six 4^{th}-year students of an academic department in a Greek university. Twenty students were female (43.5%) and twenty-six were male (56.5%). None of the students had had any previous experience with ADs, while all students had extensive experience with computers. During the interviews, students interacted with ADs that presented the development of web pages using a popular commercial application. Interviews averaging approximately 75 minutes in length provided quantitative and qualitative information about students' attitudes towards ADs. The interviews included four activities.

In the first phase of the study, students completed a questionnaire consisting of 4-point Likert scales, regarding their level of knowledge of web development and common desktop applications, their interest in developing web pages and their prior experience with ADs and the commercial application to be learnt. In order to identify the origins of students' prior computer knowledge, they were also asked to specify the sources of their knowledge about five computer content areas: programming, office applications, internet applications, games, and operating systems. Ten alternative sources that have been widely discussed in literature (Palaigeorgiou, Siozos, Konstantakis & Tsoukalas,

2005) as potential channels of computer knowledge were presented as possible answers: books, magazines, help system, internet, hands-on experience, television and radio, ICT in school, family, friends and educational multimedia applications. Students could select up to three sources for each content area, ordering them by their relative importance.

In the second phase of the study, students were requested to use an educational application that incorporated an extended set of ADs for learning about the development of web pages. ADs covered the full range of the software's functionality, lasted 2 to 10 minutes, and were organized in scenarios that showed the construction of sample web pages. ADs included the typical features that are widely encountered in commercial applications. For example their flow could be controlled by common navigating buttons, such as those used by most media players. Students were asked to use the educational application freely for 25 to 35 minutes, and to choose and watch the ADs according to their preferences. We expected that developing web pages would be an intriguing learning task.

In the third phase of the study, semi-structured interviews were conducted. These interviews lasted approximately 30 to 40 minutes and were tape-recorded. Interviews were focused on identifying the students' attitudes towards ADs after their initial use. Students completed a short questionnaire consisting of seven 5-point Likert scales that quantified their perceptions and beliefs about ADs.

In the fourth phase of the research activity, students were asked to use an alternative type of ADs to learn about the same application. Those ADs were organized in short steps and, at certain points, required students to execute sequences of actions in a simulated environment as a means of reinforcing the students' comprehension of the presented material. Students used those ADs for about 10 minutes and then commented on them in comparison with the ADs they had previously explored.

Finally, all audio-taped interviews were transcribed. Follow-up discussions among the authors were conducted and major themes were identified through examination of repeated references made by the participants.

Results

Prior experience and sources of computer learning

The questionnaire about prior experience affirmed that none of the students had previous experience with ADs. Despite the fact that their knowledge of HTML and web page development was relatively limited (M=2.06, S.D.=.95), they were greatly interested in web authoring tools (M=3.22, S.D.=.66). Conversely, all students had extensive experience with common desktop applications such as text editors and spreadsheets (M=3.61, S.D.=.65).

In order to examine the sources of students' prior computer knowledge, ten variables were calculated for each of the five content areas of the questionnaire (programming, office applications, internet applications, games, and operating systems). These variables corresponded to the importance of the ten knowledge sources for the related content area. Sources selected by the students were assigned a value (1 to 3), depending on their prioritization by students, while the rest of the variables were set to 0. The average use of each source was estimated as the mean of its usage for the five content areas. Table 1 shows the students' use of various knowledge sources for the content areas under consideration.

Table 1. Knowledge sources use for different computer applications

	HonE	*Friends*	*School*	*Book*	*Magaz.*	*Internet*	*H.S.*	*Family*	*EA*	*TV&R*
Oper. System	1.54	1.39	0.26	0.61	0.89	0.50	0.17	0.20	0.00	0.00
Office Applications	2.44	0.96	0.20	0.61	0.22	0.33	0.54	0.09	0.09	0.00
Programming	1.65	0.44	2.24	0.83	0.04	0.09	0.11	0.00	0.00	0.00
Games	2.02	1.57	0.00	0.00	0.48	0.22	0.07	0.04	0.00	0.07
Internet	2.24	0.72	0.50	0.22	0.57	0.83	0.04	0.09	0.00	0.00
Average	1.98	1.02	0.64	0.46	0.44	0.39	0.19	0.08	0.02	0.01

HonE, hands-on experience; H.S., help system; EA, educational applications; TV&R, television and radio

Students' responses supported our initial claim regarding the lack of adequate electronic sources for computer learning. As shown in Table 1, they developed their computer skills mainly through hands-on experience and social environment's help. For example, the most important sources for student's knowledge about office applications were hands-on experience and their friends' help. Similarly operational computer knowledge had also emanated from friends and personal efforts. Electronic forms of support, such as the Internet, help systems, and educational applications had limited contribution to their knowledge.

Students' answers also revealed that their learning strategies were differentiated into distinct types of software. For example, students' knowledge about Internet applications originated mainly by hands-on experience, while their knowledge about programming resulted from hands-on experience and school. Consequently, the appropriateness of ADs should be examined relative to the corresponding knowledge field.

Interview results

Semi-structured interviews questions were focused on students' beliefs about AD quality and appropriateness for learning different applications in various contexts of use. We analyzed and organized students' remarks along two axes: the first one refers to the perceived comparative advantages and shortcomings of learning through AD, while the second one concerns the investigation of causes that provoke students' differentiated attitudes. A brief description of the study's results is shown in Figure 1.

Perceived comparative advantages and shortcomings

Perceived advantages

ADs were praised for their authentic representation of task sequences. Students indicated that ADs accurately and cohesively displayed the continuity of user actions and system responses (e.g., *all actions seemed to be happening in real time and that helped me better comprehend the corresponding operations*). Furthermore, they thought the ADs expressly conveyed information that was only tacitly communicated by other knowledge sources, such as books and web pages. For example, ADs demonstrated the required mouse movements for executing an operation, the changes in focus involved, and the time typically necessary to perform a task (e.g., *if you watch the video, you will know how things happen, while, when reading a book with images, you expect that some things will not be described)*. ADs' realistic representation of the software's operational environment gave students the impression that they were executing tasks along with the narrator. Interestingly, many times, interviewers noticed students trying to take control over the demonstration and perform operations on the simulated environment. In some cases, students claimed that they felt as though they had executed the displayed operations and, hence, there was no need to try out the same tasks in the real environment (e.g., *while watching the sequence of the steps, you have the feeling that you are the one who executes the tasks*).

All students evaluated ADs' educational value relative to traditional instruction models and did not compare it with other electronic knowledge sources. According to students' remarks, ADs can simulate one-on-one teaching in an exceptional manner (e.g., *I felt as if I had a teacher or a friend showing me how the application worked*). Students argued that the new environment had one main advantage over the traditional one: it provided more control and autonomy over their learning. Students had the opportunity to select the topic to be learnt, and replay the AD's content whenever they wished so as to satisfy their immediate needs and preferences. Additionally, a few students assessed in quite positive terms the absence of emotional inhibitions that can impede the learning process (e.g., *I am not the kind of person who feels comfortable asking questions; in those demonstrations I just have to watch again whatever I do not understand).*

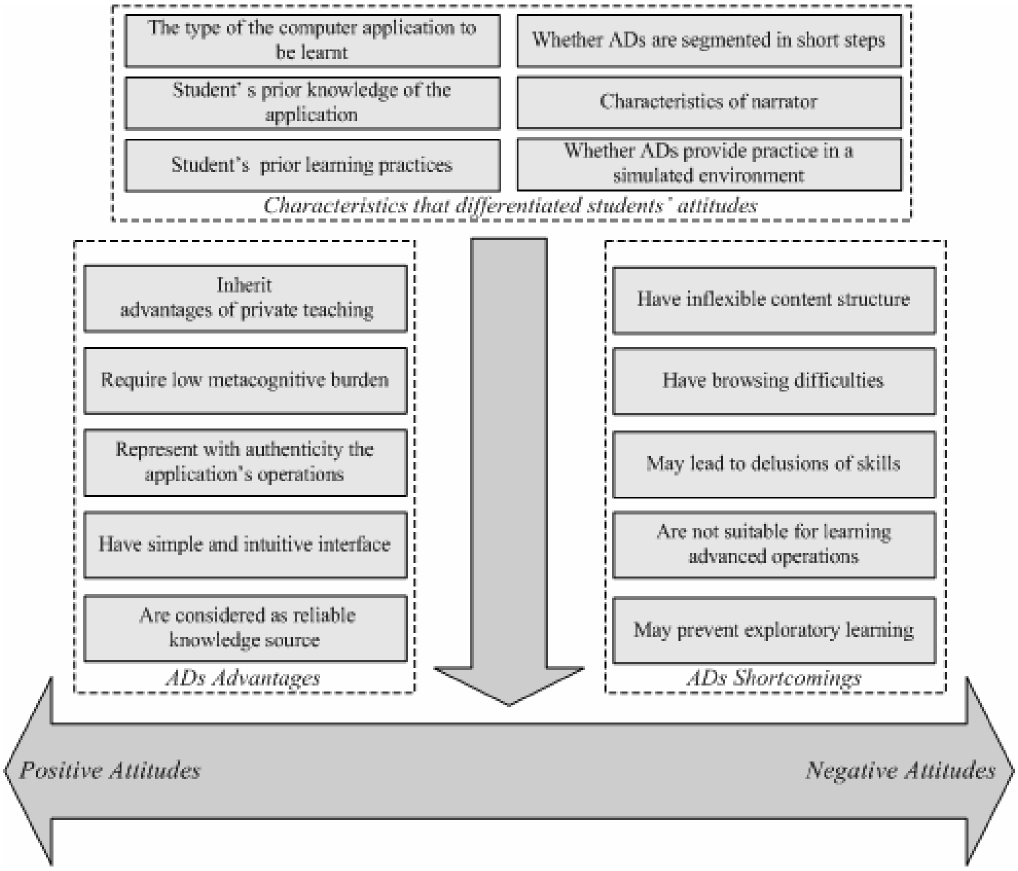

Figure 1. Study results

Students commented that ADs did not place significant metacognitive burdens on their comprehension. Students expressed their general learning objectives by selecting ADs and then they followed the learning path promoted by the ADs' authors. Their attention was directed by the AD narrator and they could simply replay those parts of the demonstrations they did not understand. According to some students, these characteristics rendered the learning process more pleasant. They stated that ADs could also be used when their concentration skills had ebbed (e.g., *I am not bored of using such applications. I usually stop reading a book when I am tired but I would probably continue to watch the video),* while some of them attributed entertainment characteristics to ADs (e.g., *even if I had low interest in this software, I could watch an AD, as I would read a novel*).

ADs were considered as reliable knowledge sources. Students assumed that authoring and production of ADs was time-consuming and presumed that their contents, by virtue of the time expended in their development, should be valid. Furthermore, almost all of the students stated that the ADs' interfaces were intuitive and familiar to them from other applications and devices they had used in the past (e.g., media players).

Perceived shortcomings

Several students contended that AD presentation structure was inflexible and sometimes inadequate to satisfy their learning preferences and needs. They could select ADs according to their objectives, but they felt both constrained and obligated to follow a predefined learning path that might not match their precise needs. For instance, a number of students claimed that the presentation was too fast and sometimes the pace exceeded their ability to assimilate the presented content. Others suggested that the narrator was verbose, since he described many operations of no interest to them. Similar user comments have been mentioned by Haas, Brown, Cao & Wilbur (2005).

Students also pointed out ADs' inherent browsing limitations on two distinct levels: the one concerned the selection of ADs available for watching and the second concerned the difficulty in finding the contents' key points. Students commented that AD selection was not an easy process because their short descriptions couldn't reveal the learning content presented. As a result, students found it necessary to launch each AD and examine its contents to identify whether it might satisfy their learning objectives or not. Students also argued that locating the AD's key points, such as the presentation of a specific operation, required an exhaustive exploration of multiple ADs. Essentially, students using ADs had to "*see to select*" as opposed to the traditional "*select to see*" navigational approach that prevails in most applications (e.g., *whenever he was saying something that I knew or was of no interest to me, I had to guess its duration so I could skip it*). The AD navigation toolbar was easy to use, but it did not provide sufficient information for locating specific points of interest. These characteristics, according to students, could have a negative effect on their speed of learning (e.g., *you had to search for the operation, close and open all videos…in each case, your progress was delayed*).

Despite the fact that the majority of students evaluated ADs' instructional value quite positively, three students made an unexpected observation about their side-effects. Those students stated that the delusion of executing actions along with the narrator could mistakenly make them believe that they had acquired certain knowledge, while they had not. They also indicated that ADs might eliminate informal forms of learning, such as exploring the interface, which often produce unexpected and positive learning outcomes.

Characteristics that differentiated students' attitude

As shown in Figure 1, positive or negative evaluations of ADs seemed to be systematically influenced mainly by three factors independent of the AD (*the nature of the computer application to be learnt*, *students' prior knowledge about that application,* and *students' prior learning practices*) and three characteristics of the AD (*narrator's characteristics*, *the offering of simulated practice,* and *the segmentation of the presentation in short steps*).

The nature of the computer application

We have noticed differences in students' evaluation of ADs' learning efficiency for learning different types of applications. Students had already developed distinct learning strategies for various types of software and, consequently, the ADs' appropriateness was evaluated in the context of the corresponding learning strategies. For instance, as indicated in previous research (Rieman, 1996), several students in our study claimed that, when they start learning an application consisting of familiar interaction objects (e.g., such as documents or drawings), they prefer to explore its functions by themselves. In this way, as they stated, they "*skip the psychological overhead of following a systematic learning process*". However, the overwhelming majority of the students commented that ADs would be their preferred choice, in case the exploration proved insufficient. Students also differentiated their assessment of ADs for learning applications that require substantial conceptual knowledge and do not incorporate complex interface features (e.g., programming environments). Students indicated that they considered other knowledge sources, such as books, to be more suitable for presenting theoretical concepts and schemas.

Students' prior knowledge of the application

Students' attitudes towards ADs were also differentiated according to students' prior knowledge of the application to be learnt, supporting Palmiter's (1993) corresponding claims. All students highlighted the ADs' significance in the initial stages of the learning cycle (e.g., *ADs are definitely more useful for novice users of an application*). However, more experienced web page developers said that it would be difficult to acquire a deeper understanding of complex operations without using any other sources (e.g., *an expert user, who usually requires more detailed descriptions will probably find ADs boring and quite slow*). Almost all students, when asked whether they would recommend ADs to their friends, answered that this would depend on their friend's knowledge level of the application. The relationship between the students' prior knowledge with their attitudes towards ADs will be further examined later.

Prior learning practices

Participants seemed to have developed tenacious beliefs about how the instructional presentation should be structured in order to be useful. Some of the students asked for a more function-oriented presentation, emphasizing that short ADs focused on specific tasks could accelerate learning (e.g., *ADs should be function-oriented to find them quickly and learn exactly what you want*). Those students stressed that, in this manner, ADs would seem more objective and they wouldn't have to watch an entire usage scenario to learn about a single operation. Conversely, other students were in favor of scenario-based ADs and stressed the advantages of watching the progressive development of pilot products (e.g., *I would like to select from a list of case studies and watch scenarios of the development of real web sites, such as a company's web site; it is more interesting*). Those students claimed that scenario-based learning is more motivating and can help them to make the coherent connection among the application's various functions. It is possible that students' preferences might emanate from their different learning styles.

Narrator's characteristics

Various characteristics of the narrator were identified as significant determinants of students' evaluations. Narrator's voice tone and accent, his style of commenting and presenting the various operations (e.g., joking, the method and speed of moving the mouse, the use or avoidance of keyboard shortcuts) colored the students' evaluations about ADs. For instance, several students were enthusiastic over the first narrator's friendly and humorous style, while they complained about the second narrator's literal method of presenting the application's operations (e.g., *the presenter's voice is awful*). Others noted that they would prefer a less personal and a more formal presentation (e.g., *this friendly style is annoying. I would prefer a more technical, less colorful style*).

Simulated practice

With regard to the use of ADs which were presented in the last part of the interview, students expressed contrasting preferences. The ones who liked practicing in a simulated environment commented that those ADs provided the opportunity to immediately apply what they had learnt in a safe environment and, hence, they could better comprehend the demonstrated tasks (e.g., *in the simulated environment, I can virtually complete tasks without the risk of making a mistake or messing up the application's settings… you participate and you feel more creative and happy with the result)*. On the other hand, some students believed that this form of "pretended" practicing resulted in only a mimicked implementation of the given instructions and offered them no benefit. (e.g., *I was frustrated. I was trying to understand and at the same time I had to do what was asked. I do not believe that I would learn better in that way because this kind of practice is disruptive*). Those students characterized the interaction with the simulated environment as a poorly designed dialogue (e.g., *you feel like a child in that you have limited capabilities in understanding; it guides you too much*) and claimed that it introduced new navigational problems (e.g., *you have to repeat all of the preliminary steps to watch again a particular task*).

Segmenting ADs

Segmenting of ADs into smaller steps is considered to enhance learning (Harrison, 1995). In our research, this feature was positively noted by several students who argued that, eventually, they could manage to adhere to the learning pace of the presentation. However, the rest of the students were reluctant to use the additional navigational elements that would allow them to alter the progression of the video, underlining that segmenting the AD into smaller steps eliminated the ADs' basic advantage, that of the continuous and cohesive presentation of an operation.

Attitudes questionnaire

Generally, most students were enthusiastic about their experience with ADs but, as previously mentioned, they also highlighted several problems. Students' answers to the closed-type questionnaire are presented in Table 2. The questionnaire was coherent with a Cronbach's alpha of .90. Students' responses were negatively skewed and underscored their positive attitudes towards ADs as computer learning tools. Most students evaluated ADs as pleasing (M=4.41, S.D.=.98) and the overwhelming majority indicated that they would like to learn about computer applications using such demonstrations (M=4.28, S.D.=1.09). ADs were accepted with greater enthusiasm by females ($t=2.043$, $p<.05$), who evaluated more positive the efficiency ($t=2.423$, $p<.03$), the speed ($t=2.553$, $p<.03$) and the authenticity ($t=2.599$, $p<.03$) of learning through ADs.

In order to examine the relationship between the effect of students' prior knowledge of the web development application and their attitudes towards ADs, a median split on the variable of perceived knowledge was performed. Excluding students which had scored on the median, the split produced two groups of students: the first group represented those less knowledgeable of the application and consisted of 21 students, while the second group consisted of 17 students. Independent sample *t*-tests indicated significant differences in students' attitudes towards ADs ($t=2.396$, $p<.03$), with the less knowledgeable students evaluating ADs more positively. These results lend further support to the previous conclusion regarding novice users' preference for ADs.

Table 2. Students' answers to the closed-type questionnaire

	Total		*By Gender*				*Gender Differences**	
Questions	M	S.D.	Male	SD	Female	SD	t	Sig
ADs enable me to learn about applications in a more efficient way compared to other means (e.g., books, web pages, etc.)	4.07	1.12	3.73	1.15	4.50	0.95	2.423	0.020
The use of ADs can make computer learning faster	3.80	1.14	3.46	1.24	4.25	0.85	2.553	0.014
ADs make computer learning more authentic	3.87	0.98	3.58	1.10	4.25	0.64	2.599	0.013
ADs make computer learning more pleasant	4.41	0.98	4.27	1.12	4.60	0.75		
I would prefer to learn about the functionality of computer applications using Ads	4.28	1.09	4.15	1.16	4.45	1.00		
I am very satisfied from the ADs I selected and watched	4.15	0.99	4.12	1.11	4.20	0.83		
I would recommend ADs to my friends who wanted to learn about new software	4.20	0.93	4.12	1.11	4.30	0.66		
Scale	4.11	0.82	3.92	0.97	4.36	0.48	2.043	0.048

**Differences are computed using independent samples t-test*

Discussion

Our study reconfirmed that ADs constitute an appealing computer learning approach (Weiss, Knowlton & Morrison, 2002; Shneiderman & Plaisant, 2005). Students' perceptions were close to other studies' arguments. ADs were perceived as advanced instruction sessions in which students specified objectives and interests, and teachers presented adequate learning scenarios. This type of learning was considered to be particularly suitable for learning about computer applications, since it simulated accurately the real environment and conveyed knowledge that was tacit to other learning means (e.g., web pages or books). Students stated that ADs required low metacognitive efforts and could even be considered as a form of entertainment. However, students suggested that ADs in their current form have significant shortcomings. For example, students noted their inflexible content structure, their browsing inefficiencies and the possibility to lead to delusions of skills.

The results indicated four directions leading to improvement of ADs. The first one is related to the development of adaptive services. Students' comments revealed various opportunities for improvement, such as, adapting the content's structure to the students' prior knowledge and prior learning practices, or adapting the presenter's voice and behavior to match more closely the students' socialization preferences.

The second potential category for enhancements stems from the positive evaluation of simulated practice by many students and from the observation that students were trying to interact with the simulated environment during the presentation. Until now, ADs have been developed as distinct applications with limited capabilities to reproduce the functionality of the application. No research studies have examined ADs that are embedded in real applications and take advantage of their original interface and functions in their scenarios. Such ADs might enable students to develop exploration activities in parallel to the presentations.

The third area offering room for improvement involves the internal and external indexing of ADs. Visualization techniques, such as fisheye views of ADs' critical frames, could provide more useful information about their contents. The creation of links to specific points of interest within their scenarios could also improve the ADs' ability to better satisfy the students' needs.

Finally, since students have stated that they are willing to use ADs during periods of low concentration levels or for entertainment, it would be interesting to design ADs that meet those exact circumstances.

We have to underscore that the results of our study were entirely focused on students' first impressions of ADs. Hence, they should be generalized with caution. Extended usage of ADs is likely to provoke more refined attitudes. Our future research aims to examine the previously mentioned improvement opportunities.

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A Learning Framework for Knowledge Building and Collective Wisdom Advancement in Virtual Learning Communities

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ABSTRACT

This study represents an effort to construct a learning framework for knowledge building and collective wisdom advancement in a virtual learning community (VLC) from the perspectives of system wholeness, intelligence wholeness and dynamics, learning models, and knowledge management. It also tries to construct the zone of proximal development (ZPD) of VLCs based on the combination of Vygotsky's theory of zone of proximal development and the trajectories of knowledge building. The aim of a VLC built on the theories of constructivism, situated learning, and knowledge building, etc., is to apply individual intelligence to online learning, bring the advantages of collaborative learning and collective wisdom into play, solve difficult problems in independent learning, and lead to the integration and sublimation of collective wisdom through long-term individual interactions, collaborative learning and knowledge building.

Keywords

Collective wisdom, Knowledge building, Virtual learning community, Collective intelligence, Knowledge management

Introduction

Educational Challenge in a Knowledge Society

The greatest challenge to education in a knowledge society is not how to effectively help learners to acquire a defined set of knowledge and skills, but in helping them to learn how to manage, work creatively with ideas and to contribute to the creation of new knowledge (Law & Wong, 2003). In knowledge building discourse, ideas, theories, hypotheses, and other similar intellectual artifacts are objects of inquiry to be scrutinized, improved, and put to new use as participants engage in progressive discourse analogous to the inquiry processes of research communities (Bereiter & Scardamalia, 1996). While education traditionally focuses on learning for which the goal is to enhance personal knowledge, in the knowledge building approach to education, the focus shifts to the construction and advancement of collective knowledge (Lamon, et al., 2001), and to interactive and collaborative learning from individual learning in a non-contextual situation (Gan, 2005, p.231).

Education in a knowledge society should enable learners to participate in the creation of new knowledge as a normal part of their lives (Scardamalia & Bereiter, 2003a). Education and practice need to undergo a revolution to become "idea-centered" from "activity-centered," and to become collaborative learning from independent learning, so that learners can embark on a knowledge building trajectory from a young age to prepare for the challenge (Scardamalia, 2002). Thus it is essential to construct and cultivate learning environments such as learning communities, organizations, campuses, etc., for learners to develop these abilities. With the development of information and communication technology (ICT), A virtual learning community (VLC) using knowledge building principles and practice (knowledge building community) is a powerful environment that immerses learners in the efforts to advance the frontiers of knowledge as they perceive them (Scardamalia & Bereiter, 2003b), and has the potential to become one of the most suitable environments for meeting these requirements (Scardamalia, 2002).

Virtual Learning Communities and Related Studies

With the booming development and exponential growth of VLCs, more and more studies have been conducted on how VLCs affect learners learning experiences, behaviors and effects by providing online interactive learning environments (Seufert, 2002; Ahern, Peck, & Laycock, 1992; Brown, 2001); and on how collaborative learning (O'Neil, et al., 2003; Stahl, 1999), collective knowledge building (Scardamalia & Bereiter, 1996; Scardamalia, 2002), knowledge management (Ubon & Kimble, 2002; Watanabe, 2001), and constructivism (Hughes & Daykin, 2002; Carr, et al, 1998), situated learning (Lave & Wenger, 1991; Oliver & Herrington, 2000) can be applied and brought into effect in VLCs. These studies have revealed the different characteristics of VLCs from various perspectives and profiles, and gained significant insights for comprehensively understanding VLCs. A few studies also researched the development of collective intelligence and wisdom in the network and community environment (Lévy, 1997; Smith, 1994; Harasim, 1990; Hakkarainen, et al, 2004; Pór, 1995; Heylighen, 1999; Nellen, 1999).

A V*irtual Learning Community* is a virtual learning environment in which a group of learners, who join together with common interests and the same learning objective, communicate, interact, discuss, and collaborate on a problem that has arisen from active learning, collaborative learning, and knowledge building, and then share each other's opinions, ideas, resources, knowledge, experiences, and collective wisdom. A VLC therefore fosters the advancement of knowledge building and collective wisdom, and learners ultimately achieve learning targets and acquire the abilities of learning how to learn to a higher level (Gan, 2005, p.39).

VLCs have the potential to change the dynamics of traditional classroom interaction and learning. However, the way of integrating different theories to research into the various profiles of VLCs has not been fully explored (Gan, 2005, p.9). This study therefore represents an attempt to research into the detailed characteristics of VLC and build an integrated framework through combining systems theory, multiple intelligences, e-learning, and knowledge management; and hopefully to offer a new and broad angle to view the development of VLCs.

Research Tasks

- A VLC is a systematic phenomenon which is composed of learners, teachers/facilitators, resources and environment. With a systems view of a VLC, this study analyzes the systematic characteristics and overall effects of a VLC, and creates a more comprehensive understanding the complexity of the relationships of its components.
- A VLC acts to amplify the collective intelligence of a group (Smith, 1994, p.4-6). When learners are facing a problem that is too large or difficult for one person to handle alone, they resort to the collective strength of a VLC. We examine the intelligence continuum in a VLC, and the processes of how collective wisdom can be integrated from individual multiple intelligences and collaborative intelligence to form collective intelligence to solve a problem.
- A VLC is an online learning organization. While no one member of the VLC possesses all the skills and knowledge that are required for solving a problem or fulfilling a task, members can interact and collaborate with each other to find a solution for the problem or task, and to enhance their higher-order cognitive skills of problem-solving and creative thinking in the long run. In this study, we explore the characteristics of different learning models in a VLC.
- A VLC is a community of practice with valuable knowledge capital and culture. We explore the processes of knowledge conversions between explicit knowledge and implicit knowledge, and four important components of a VLC from a viewpoint of knowledge management: personal knowledge management, learning organization, organization memory and organization culture.
- A VLC can be developed into a knowledge building community through putting the principles of knowledge building (Scardamalia, 2002) into practice. We try to summarize the cognitive processes of idea convergence and the trajectory of knowledge building, and bring forward the zone of proximal development of a VLC.

We frame and address these problems to guide our research and try to construct an integrated framework for knowledge building and collective intelligence advancement from a systems view through the integration of systems theory, collective intelligence and collective wisdom, learning models, knowledge management and knowledge building.

Learning Framework for Collective Wisdom Advancement

Collective Wisdom is a sustainable human ability that is created and fostered by the contribution of individual talents, skills, and diverse experiences to support a common purpose; it is also a dynamic ecosystem for individual and collective learning in which emergent patterns of meaning, coordination flows, insights, and inspiration interact, cross-fertilize, feed upon, and grow on each other (Pór, 1995). Thus, collective wisdom can be defined as the ability to gain a profound insight into deep understanding the essence of the world, which is derived from the processes of divergence, convergence, integration and creation of individual members' multiple intelligences in a group/team, organization or the whole society (Gan, 2005, p.70). As we come into a knowledge society, this collective ability becomes of fundamental importance.

A four-level framework can be constructed to analyze the advancement of collective wisdom from the perspective of the technological structure (See Figure 1):

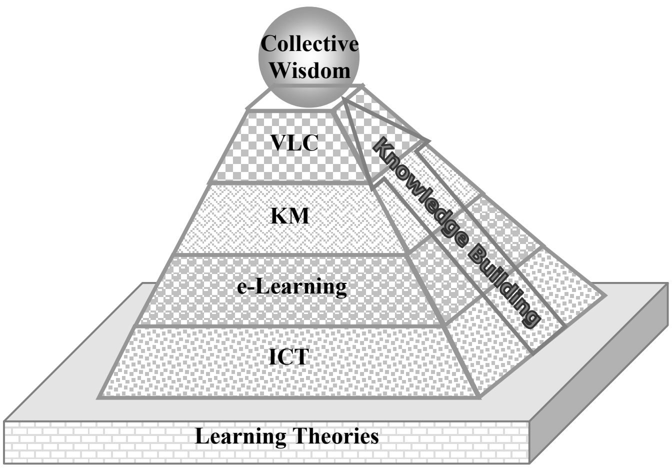

Figure 1. A four-level framework to support collective wisdom in learning communities

- *Information and Communication Technology* provides the network environment for the spread of collective wisdom far and wide. It is a new model of wisdom, in which every new idea is merged into the next new idea and then it produces a new understanding about the essence of being a human and the universe in which we live, that can be shared and spread through the new-born network connected around the world (Willard, 1981).
- *e-Learning*, which is extending toward digitization, networking, multi-media and artificial intelligence, is becoming the main platform for online/distance education and life-long learning as its software packages and platforms prevail, and is causing a magnificent transformation of learning models (Jansen, et al, 2002; Gan & Wang, 2005).
- *Knowledge Management (KM)*, which is becoming more and more important in the knowledge society, "combines the processes and application of technological tools to digitize, store, and make universally available, via electronic networks, the continuing creation and transference of knowledge and wisdom throughout the life cycle of the educational experience" (Galbreath, 2000).
- A *VLC* provides a flexible and open learning environment for practicing knowledge building, collaborative learning and converging collective wisdom, in which learners communicate information, discuss problems, pose new ideas, extend points of view, exchange learning experiences, debate opinions with each other and share a common understanding, and they also acquire, classify, store and share knowledge. Thus, learners not only have acquired new knowledge, but they also have attained the abilities of learning how to learn, enhancing their multiple intelligences, teamwork and collective wisdom (Gan, 2005, p.160).

Collective wisdom in a VLC can be viewed as a dynamic, living "ecosystem" for individual and collective learning in which learning groups/collective cooperatively enhance the wholeness and interconnectedness to deepen the understanding of knowledge and to progressively integrate the individual intelligences. As a result, the VLC can attain higher-level wholeness and closer connectedness to shape the abilities of co-creation.

This study builds up a learning framework for knowledge building and collective wisdom advancement in a VLC from system wholeness, intelligence wholeness and dynamics, learning models and knowledge management (See Figure 2).

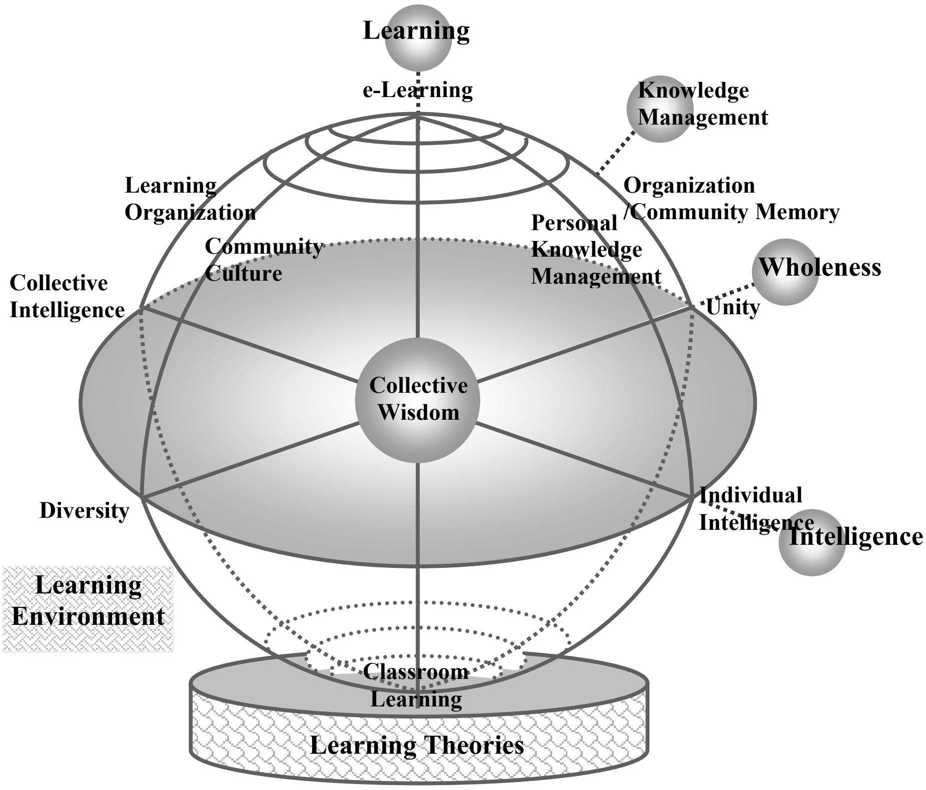

Figure 2. A learning framework for knowledge building and collective wisdom

Theoretical Analysis and Discussion

Systematic Wholeness Dimension

Unity and Diversity

Wholeness is the most basic and essential attribute of the system. Unity and diversity are two important attributes of wholeness (Harung & Harung, 1995). Unity is the common and general attribute of the system elements that interconnect and link various system elements and shape them into a united, dynamic wholeness. Diversity is the individualism and uniqueness of the system elements and the differences among system elements.

A group, an organization, a community, and society are different examples of united wholeness. Unity and diversity are the two most important perspectives in order to analyze the qualities of an organization and its members. People are organized to be a unity because they share common interests and have the same destination, but every member has many differences in personality, learning style, capability, intelligence level, and so on. It is just as Gardner said that the core perspective of multiple intelligences, whether in theory or in practice, lies in taking personality diversity seriously into account (Gardner, 1983).

Some scholars have dealt with the relationship between the learners' personality factors and the effects of online instruction (Anderson & Reed, 1998; Rasmussen & Davidson, 1998; Charlton & Birkett, 1999). A comparative experiment was also carried out (Wang, Li, & Liu, 2001), in which the relationship between online learning outcomes and five personal characteristics and educational attitudes such as perseverance, experimenting factor, creativity, ability to grow up in a new environment, and gender, were respectively researched. The results revealed that the learners' personality factors influenced the outcomes of online instruction to a great extent and different online instructional patterns should be offered to different learners based on their personal characteristics. A comparative experiment on the correlation between the learners' personal characteristics and computer-mediated communication (CMC) (Tolmie & Boyle, 2000; Wilson, 2000) was also carried out (Wang, Yang, & Liu, 2002), in which the relationships between personality factors, learning style, learning achievement, gender and computer-mediated communication were respectively researched. The results showed that these factors had a great influence on computer-mediated communication.

Systems Dimension

Systems theory insists that the universal relationships between system and system, system and components, system and environment must be studied from the perspectives of wholeness, connectedness, dynamics, hierarchy and self-organization (Daniel, 2006). A systems view enables us to explore and characterize the system of our interest, its environment, and its components and parts (Banathy, 1996, p.47). A VLC, which is organized around a certain purpose and composed of learners, teachers, facilitators, support staff, resources, network, and so on, has its relevant constituents, structures and features, and is a cohesive systematic whole. The learning characteristics of members in a VLC can be illustrated by two aspects: unity and diversity. Thus a VLC, in which learners do various learning activities as a collective in different groups or teams, is a hierarchical and structural system (Gan, 2005, p.154). The main characteristics therefore can be analyzed using the following four aspects (See Figure 3).

Hierarchy/Variation. As for the learners in a VLC, there are too many differences in their grown-up environment, life experience and cultural background; there are too many different features in personality, learning style and learning method; there are too many various levels in knowledge, cognitive ability and critical thinking ability; and there are also too many varieties in social communication, moral spirit and personal character. Thus, individuals in a VLC present too much diversity and variation. This variation is just like an unmagnetized magnet whose uniaxial magnetic poles are anisotropic.

Relevancy/Synergy. The learners mutually associate and influence each other in a VLC. The learning environment of a VLC will be destroyed if it is not suitably maintained. If a VLC is to be successful, one of the important factors to be manipulated is the community unity in learning destination, interest and commitment, and to make them synergize with one another -- that is, to produce a positive correlation rather than a negative one, to fully present learner specialties, and to facilitate the relevant factors towards the advancements in learning new knowledge, increasing learning performance, a higher cognitive level and advanced collective wisdom. This synergy is just like a magnetized magnet whose uniaxial magnetic poles are isotropic.

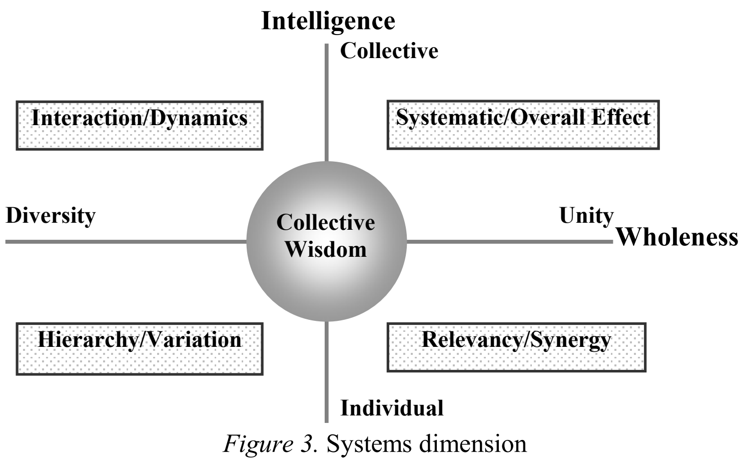

Figure 3. Systems dimension

Interaction/Dynamics. New knowledge is built and emerged in social dynamic interactions (Nonaka & Konno, 1998). The learner-centered learning in a VLC is mostly collaborative learning. It is a process of learners exchanging information, teaching and learning from one another, and also a process of taking care of each other, communicating feelings and exchanging opinions. During this, learners will experience a feeling of being accepted, trusted and identified by others through participating in activities, sharing outcomes, holding discussions and evaluating the achievements of one another. This extends the rich surroundings for enhancing social intercourse, cultivating communication skills, and developing self-awareness and a sense of community. Collaboration in a VLC also greatly increases individual collaborative capabilities and teamwork spirit by way of inspiring new ideas and the encouragement of one another (Gan, 2003a).

Systematic/Overall Effect. The overall effect is the most basic and important point in the systems theory view which insists that the whole function of a system is larger than the sum of the isolated elements respectively. Not only are the learners in a VLC independent from each other, but they also are interdependent and mutually restricted; therefore a VLC is an organic learning organization and system. The convergence of intelligence and wisdom in a VLC is an embodiment of this system effect. However, a VLC cannot necessarily give rise to a "positive" system effect; it can possibly bring out a "negative" system effect. If a VLC is expected to be successful, certain measures and means such as the applications of technical tools, learning environment design, learning resources, learners' participation and interaction, learning commitment, information exchange and mining, knowledge sharing and knowledge management, must be taken into account to develop the "positive" system effect, and facilitate the emergence of new knowledge and the crystallization of collective wisdom in a VLC.

Intelligence Dimension

Collective Wisdom Continuum

The development of collective wisdom can be viewed from two aspects: from individual to collective and from intelligence to wisdom, so the advancement of collective wisdom can be identified as four stages (Gan, 2005, p.72) (See Figure 4):

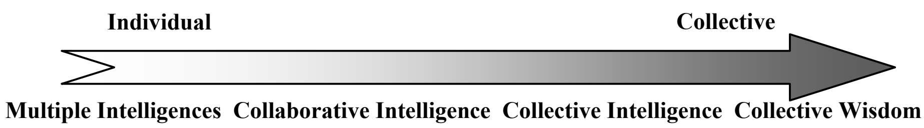

Figure 4. Collective wisdom continuum

Individual Multiple Intelligences. Howard Gardner (1983) formulated a list of eight intelligences: linguistic, logical-mathematical, spatial, kinesthetic, musical, interpersonal, intrapersonal, and the naturalist, which are the abilities of applying the whole spectrum of individual intelligences. Gardner suggests that different intelligences may be independent abilities -- a person can be poor in one area of skill but excellent in another domain. All of us possess the eight intelligences but in varying degrees of strength and skill.

Collaborative Intelligence. When a team participates in high-engagement activities, connecting with one another, a different kind of value -- collaborative intelligence -- is being created. Collaborative intelligence is the ability of a group or team collaborating with each other effectively, producing synergy and exerting all the strength of a team to an extreme extent. It is also the ability of synergy produced from the environment in which we live and the relationship with the environment with which we interact (Gan, 2005, p.73). Collaborative intelligence can be worked as an "intelligence amplification" (Smith, 1994, p.4-6) which could enable group thinking on a scale and level of significance that it has been impossible for individuals.

Collective Intelligence. "The notion of collective intelligence is that a group of human beings can carry out a task as if the group, it self, were a coherent, intelligent organism working with one mind, rather than a collection of independent agents" (Smith, 1994, p.1). Many experts have studied this phenomenon and listed many examples (Bonabeau et al., 1999; Heylighen, 1999; Susi & Ziemke, 2001). Collective intelligence is the ability of a group, a team, an organization, a community and the whole society to learn, to solve problems, to plan the future, to understand and to adapt to the internal environment and the external world, with the convergence of individual or distributed intelligence and the integration of the whole strength and unity (Gan, 2005, p.73).

Collective Wisdom. Collective wisdom can be defined as the capacity of communities to cooperate intellectually in creation, innovation and invention (Lévy, 2004), and to learn, to work, and to solve problems effectively, which works like a cohesive wholeness whose function is larger than the components. Collective wisdom is the convergence of multiple intelligences and can shape deep insights and wide views. Thus, it is a continuum from individual multiple intelligences to collective wisdom. The development of collective wisdom is a process of up-and-down and spiral advancement. Much attention has been paid to collective wisdom as the Internet leads us to a vision of a "global brain" (Heylighen & Bollen, 1996; Heylighen, 1999), and more research and case studies on collective wisdom can be available from several websites (see: www.collectivewisdominitiative.org; www.collective-wisdom.org; www.wisdomcollective.com; and collective-wisdom.com; etc.)

Collective Intelligence and Collective Wisdom

Intelligence and Wisdom. According to webster.com, intelligence is: "(1) the ability to learn or understand or to deal with new or trying situations: REASON; (2) the ability to apply knowledge to manipulate one's environment or to think abstractly as measured by objective criteria (as tests)." And wisdom is: "(1) accumulated philosophic or scientific learning: KNOWLEDGE; (2) ability to discern inner qualities and relationships: INSIGHT; (3) good sense: JUDGMENT." Thus we can see that intelligence and wisdom are separate phenomena and operating in different dimensions. Intelligence is the ability to learn, to derive knowledge from information, to analyze and combine knowledge, and to understand and to face new unfamiliar challenges. Wisdom is the ability to apply knowledge into practice, and the ability to fulfill her/his needs in harmony with environment, to comprehend ethics and morality.

Intelligence is associated with explicit knowledge, reason, and the scientific method; wisdom is associated with implicit knowledge, understanding, judgment, insight, morality, a sense of beauty and appropriate action in social situations. It's hard to have the latter without the former, but possible to have the former without the latter. All in all, intelligence is a thinking; wisdom is a knowing.

Collective Intelligence and Collective Wisdom. The differences between collective intelligence and collective wisdom are similar to that between intelligence and wisdom. George Pór (1995) defined collective intelligence as "the capacity of a human community to evolve toward higher order complexity thought, problem-solving and integration through collaboration and innovation." Collective intelligence has the possibility of thinking at a different level than that of the individual. It is seen as the confluence of distributed cognition of "cultural and social context" (Vygotsky, 1978), and the cognitive processes and structures that emerge at the social level. Collective wisdom can be thought of as the collective capability to shape a profound insight into a deep understanding of the essence of the world, by integrating individual members' multiple intelligences and strength, and close collaboration with each other, and cooperatively enhancing the wholeness and interconnectedness in a group. Collective wisdom is the product of long-term practices of a group or community with collective intelligence, and is the insight that only emerges in communities. Collective intelligence may lead to collective wisdom, but may also lead to "collective stupidity" (Heylighen, et al., 2004).

The distinctions between these concepts shown in Figure 4, just as the distinctions between the data, information, knowledge, and wisdom continuum, are not very discrete, thus the distinctions between each term often seem more like shades of gray, rather than black and white (Shedroff, 2001).

Intelligence Wholeness Dimension

Collective wisdom is a systems phenomenon. While individuals with multiple intelligences in a VLC are organized into a unity, collective intelligence and wisdom can be developed from individual multiple intelligences after a long-term practice of knowledge building in a community of practice. The intelligence dynamics can be analyzed from four progressive levels: individual multiple intelligences, interpersonal common intelligence, collaborative intelligence and collective intelligence (See Figure 5).

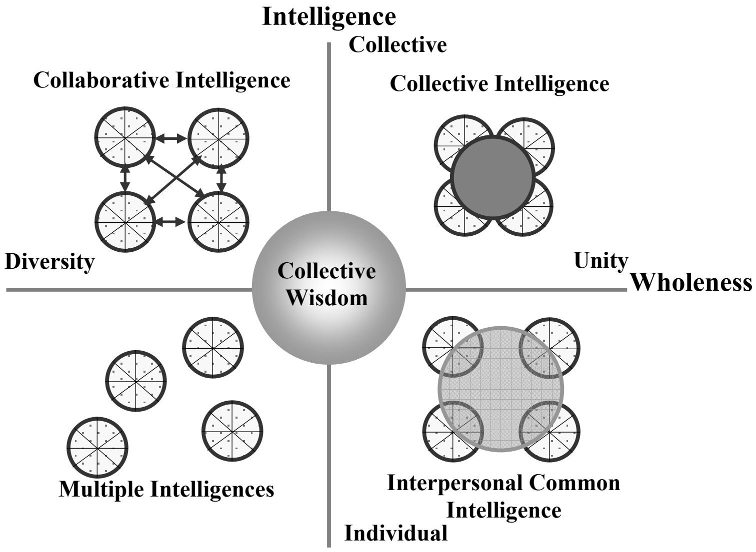

Figure 5. Intelligence wholeness

Multiple Intelligences. From the viewpoint of multiple intelligences (Gardner, 1983), every learner in a VLC has his/her own multiple intelligences with different levels and in different representations, and everyone has his/her own dominant intelligence and weak intelligence because everyone has his/her own specific characteristics of intelligence, personality and learning style. It is the differences in multiple intelligences, personal experience and cultural background that make individual learners treat the same thing/problem differently, present various opinions, and show the diversification that is the very source of creation, which is a capacity to initiate or generate new ideas that are novel and appropriate to the task at hand.

Interpersonal Common Intelligence. Multiple intelligences extraordinarily emphasize individual diversity (Gardner, 1983). Every one of the multiple intelligences is relatively independent, but all of the eight intelligences are close combined into a whole in a different way and to a different level or extent. There are two aspects of interpersonal common intelligence: (1) the similar intelligences among learners from scratch in a VLC. Although the participants in the same VLC have different intelligence levels, they have a similar average intelligence level by and large. For example, the learners who are to study a course should meet the initial requirements of this subject and have studied the relevant preceding courses. All in all, they possess the intellectual level and the knowledge requirements of this subject. (2) The outcomes of cognition and learning are similar. Learners in a VLC have a common intent and desire to attain a target. Through individual endeavor and collective collaboration, the learners' intelligences are advanced, and they achieve the learning target required by a subject syllabus and share a similar common understanding of knowledge at the end of the term (Gan, 2005, p.148).

Collaborative Intelligence. The problems posed by learners or emerged in learning in a VLC are also a good opportunity for learning. Learners understand and solve the problems through their collaborative intelligence and then enhance their individual intelligence. One of the challenges of collaboration in a VLC is how to apply individual diversity creatively and wisely because the diversities of individual learners may have a positive or negative influence on learning. Collaborative intelligence can be used to apply individual diversity to create a combined strength for collective problem-solving, knowledge building and learning targets. The representative characteristics of collaborative intelligence are as follows: learners provide help, resources, feedback for each other; query one another's opinions and explain the conclusions to one another; they trust and stimulate each other; and they also have good interpersonal ability and a willingness to work hard for a common goal through collaboration in order to attain the optimal learning achievement. Collaborative learning in a successful VLC results in the achievement of a sense of collaboration, active interpersonal relationships and high spirits.

Collective Intelligence. Collective intelligence presents the two kinds of connections of intelligence: first it confirms the independence of individual intelligence; secondly, it confirms the interaction of individual intelligence when observing an object in a complex environment (Wu, 2001). Collective intelligence is a "universally distributed intelligence" (Lévy, 1997) working with one mind, rather than a collection of independent intelligences (Smith, 1994, p.1). It is also the effective combination of distributed individual intelligence, and the collaboration and cohesion of individual intelligence; therefore it leads to fostering and improving the whole intelligence and wisdom in a VLC.

Intelligence Dynamics Dimension

The circle of spiral advancement of collective wisdom can be identified as four phases: intelligence divergence, convergence, cohesion, and innovation. The interplay of individual intelligence in a VLC also can be classified as four states: self-organization (autonomy), interconnectedness, integration, and co-creation (Gan, 2005, p.150) (See Figure 6).

Self-organization—Divergence. Every individual participant in a VLC is an independent learner who has his/her own learning plan, learning method and learning style. When learners encounter a problem, they can publish their problem in a VLC and ask for help from other learning companions. Owing to personal differences in intelligence levels, knowledge and cultural backgrounds learners treat every problem in different ways, with different visions, thoughts, and views; thus they can seek the solution in different ways and solve the same problem with different methods. As a result, different learners may produce a lot of outcomes or solutions to a problem, especially to an ill-structured problem. This is a process of brainstorming and thinking divergence.

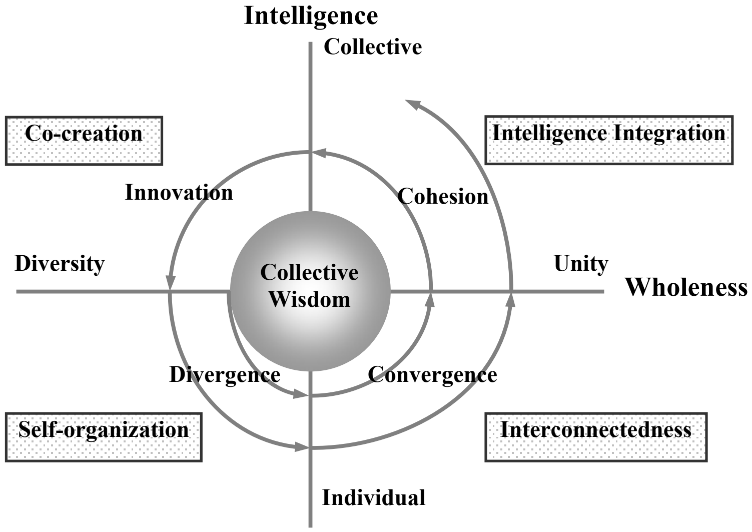

Figure 6. Intelligence dynamics

Interconnectedness—Convergence. The learners in a VLC poster their opinions about a problem, and discuss passionately. They may disprove a viewpoint and point out its shortcoming, or they may agree on an opinion, or represent an improvement on an idea. This is a process of interplay, interconnectedness and interaction among learners and a process of collective knowledge building. The facilitator in a VLC plays an important role in the process: firstly, he/she can put forward an enlightening idea or thinking clue for problem-solving. Secondly, he/she can actively pilot the direction of discussion; lead the problem-solving action to convergence; and foster the sharing of a consistent understanding. This is the process of progressive convergence of collective problem-solving.

Intelligence Integration—Cohesion. The process of learners discussing, debating and challenging a problem time after time in a VLC is also the process of learners exchanging, communicating, giving feedback, learning and self-reflecting with one another. In the meantime, it is also a process of progressively forming the learners' abilities of sharing deep understanding, gradually increasing a higher cognitive level and ultimately tending to a consistent shared understanding. Shared understanding here has two meanings: firstly, in a well-structured problem, learners can ultimately achieve a consistent problem-solving solution (possibly more than one); secondly, in an ill-structured problem, there may be more than one solution (Zhu, 1996, p. 101-104). Shared understanding here is an inclination to similarity in which a similar understanding and grasp of the core of the problem is achieved through gradually seeking common ground while reserving differences, learners therefore can improve together the abilities of deep understanding and insight. New information and new knowledge in a VLC are also exchanged and shared, and collective intelligence is progressively upgraded in the course of learning, which is definitely a long-term, spiral and accumulative process to collective wisdom.

Co-creation—Innovation. Learning in a VLC is mainly student-centered in which learners not only learn new knowledge, but also, more importantly, cultivate the consciousness of innovative thinking and creative ability. Learners cannot be satisfied with only seeking the solution to a problem, but they should acquire higher level critical thinking skills. Namely, they should exert divergent, critical and imaginative thinking, and then probe into the deep meaning behind the problem, pose new questions or new ideas, based on the previous problem that has been solved. One of the characteristics of co-creation in a VLC is that learners can creatively use their personal diversities and brainstorm the common problems in which they are interested.

Learning Models Dimension

It is a continuum from traditional schooling to e-Learning. In fact, real learning for the most part is blended learning. There are two main online learning models in VLCs: independent learning and collaborative learning. A VLC is a most suitable environment to combine the two patterns of learning models and bring them into effect (See Figure 7).

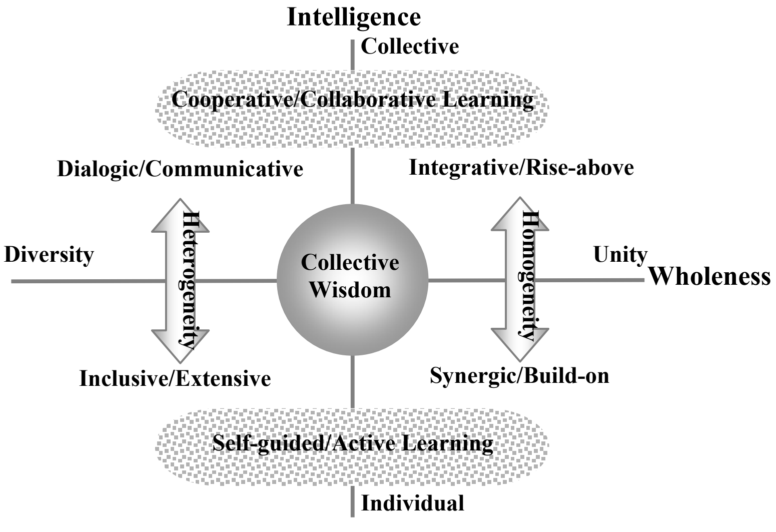

Figure 7. Learning models

Independent Learning

Independent learning (individualized learning) or self-guided/active learning in a VLC is one in which students independently choose learning contents, make learning plans, arrange timetables and places for study, with the network providing learning environment support, multiple choices of learning contents, optimal instructional support for every student, and teaching students in accordance with their aptitudes. Thereby, students can acquire and renew their knowledge through self-study.

Collaborative Learning

Collaborative learning in a VLC is an educational approach to teaching and learning that involves groups of students working together to solve a problem, complete a task, or create a product in which discussion, communication and collaboration take place among students, and between a teacher and students, with the network providing a collaborative learning environment. It leads students to cultivate a positive learning attitude, collaborative spirit and interpersonal relationships, and acquire some higher level cognitive skills (Zhu & Zhong, 2003, p.124-128).

Collaborative learning looks upon teachers and students as learning resources and an environment, in which students put knowledge building principles into practice through interaction and collaboration, and therefore presents the essence of constructivism. To make collaborative learning successful and maximize learning outcomes, the essential components of cooperation must be carefully considered such as positive interdependence; face-to-face interaction; individual and group accountability; interpersonal and small group skills; and group processing (Johnson, Johnson, & Holubec, 1993).

There are four main constructivist educational approaches to learning, which are considered as environments for facilitating students into practice, collaboration and communities of learners with the support of ICT. The four approaches are learning by design, project-based learning, problem-based learning, and knowledge building (Bereiter & Scardamalia, 2003b). Knowledge building, which can be defined simply as "creative work with ideas that really matter to the people doing the work" (Scardamalia & Bereiter, 2003a) and its basic objective is to "advance the frontiers of knowledge as these are perceived by the students," offers the possibility of integrating all the other three approaches into an overarching learning environment that provides fuller and more authentic immersion in the actual life of a knowledge society (Bereiter & Scardamalia, 2003b).

Knowledge Management Dimension

Macro-vision of Knowledge Management

The aim of learning is to acquire new knowledge and furthermore to turn knowledge into life wisdom, in which knowledge management plays more and more important roles. We can review its roles in VLCs from four aspects: personal knowledge management, learning organization/community, organization/community culture, and organization/community memory (Gan, 2005, p.165) (See Figure 8).

Personal Knowledge Management. Personal knowledge management is the key to knowledge management, successful community of practice, and successful cultures in general. Individuals should use the methods and tools of knowledge management to manage personal knowledge in view of knowledge management (Gan, 2003b). Individual learning and working, and personal amassing, organizing, storing, applying and innovating new knowledge must be combined with individual intelligence development, career design, and life blueprint to gain individual knowledge and wisdom from the vision of knowledge management. In comparison with acquiring new knowledge, the ability of learning how to learn is much more important. The objective of education is not only to attain new knowledge, but more important to foster the improvement of learning ability and individual wisdom.

Learning Organization/Community. The fifth discipline of a learning organization (Senge, 1990) provides a powerful theoretical basic and methodological guideline for a learning organization and community of practice. The new idea and knowledge presented in different stages in a VLC must be linked up and stored in the database, and the individual intelligences must be integrated to foster the shared understanding and the improvement of new idea and knowledge in the whole VLC in which instructors or teachers should try to use systems thinking and knowledge management, and make full use of various learning methods and learning tools to foster the discovery, spread, storage, sharing and innovation of new knowledge. In the course of this, the learners' learning ability, thinking power and creativity are incubated progressively.

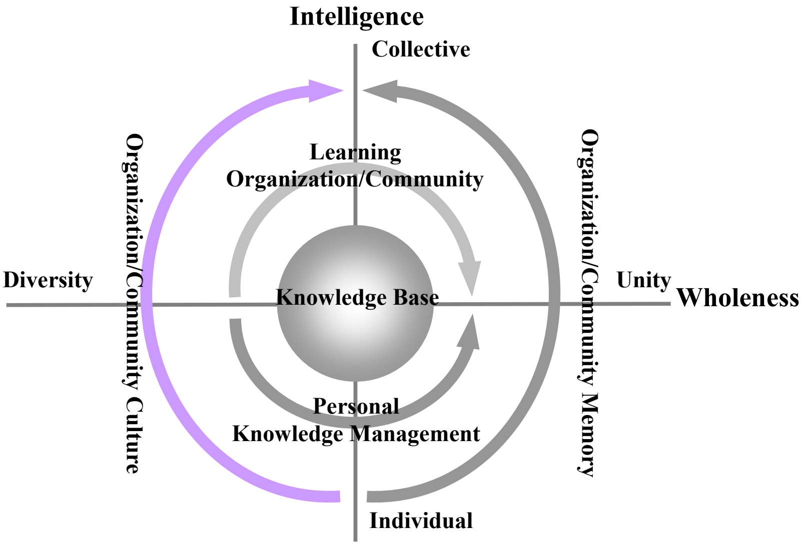

Figure 8. Four elements of knowledge management

Organization/Community Memory. Organizational memory can be characterized as a comprehensive computer system or collective memory which captures an organization's accumulated know-how and other knowledge assets, and makes them available to enhance the efficiency and effectiveness of knowledge-intensive work processes (Kuhn & Abecker, 1997). Building organization/community memory is an important stage in building a successful VLC in which the new knowledge derived from different sources must be sorted, organized, refined and stored in order to integrate isolated, scattered knowledge into organization/community memory. Knowledge engineering, case-based reasoning and agent technology provide the technological support for building organization/community memory.

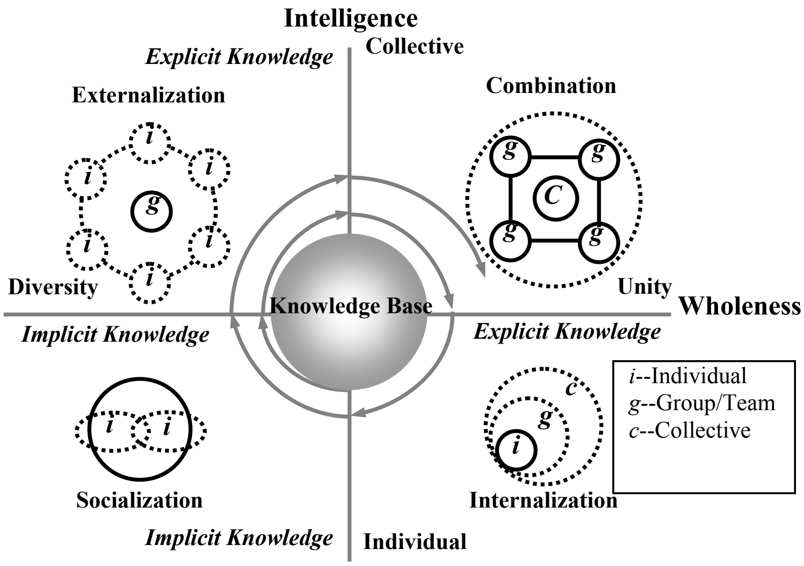

Figure 9. Knowledge conversions in a VLC

Organization/Community Culture. The most important feature of a VLC is its strong cultural maintenance which is composed of a sense of a common vision, a sense of belonging, a realization of self-worth, and so on, that can cultivate participants into stable and loyal members of a VLC. If the cultivation of the community culture is ignored, the VLC will fail as usual. Thus in the course of implementing knowledge management, change management must be paid particular attention to (Cropley, 2004), and the facilitator should foster the cultural innovation in a VLC and transform learners' traditional notions of learning (Gan & Tao, 2006).

Micro-vision of Knowledge Management

Knowledge management comes to have a double-value effect through knowledge sharing. A VLC therefore is a most suitable environment where knowledge sharing can be easily and directly achieved. A typical application of knowledge management is in a community of practice and knowledge building community.

The knowledge conversions in VLCs are based on the knowledge conversions between individual knowledge and collective knowledge. From the vision of collective, individual knowledge is implicit knowledge relative to collective knowledge. The knowledge produced through individual interactions and emerging from VLCs is collective knowledge and is owned by all members, thus it is explicit knowledge. We can describe the knowledge conversions in VLCs based on Nonaka's SECI (Socialization, Externalization, Combination, and Internalization) model (Nonaka & Takeuchi, 1995, p.63-69) (See Figure 9).

Socialization. Socialization is a process of sharing personal experiences through social interactions among learners in a VLC, and then creating new, value-added implicit (tacit) knowledge such as sharing mental models, technical skills and know-how. Implicit knowledge can therefore be spread through its socialization in a VLC. Learners acquire and transfer implicit knowledge through observation, imitation and practice in the past and at present. For instance, apprenticeship is a typical model of sharing implicit knowledge between mentor and apprentices. However, VLCs or communities of practice offer a wider range of conditions and environments for implementing the transfer of implicit knowledge among learners, and for creating new knowledge from practice.

Externalization. The externalization of knowledge in VLCs is a process in which learners convert their implicit knowledge (relative to collective knowledge) to explicit knowledge (collective knowledge) by way of dialogues and discussions among learners in which ideas and technical know-how are presented by words, pictures and diagrams, and so on. Aiming at the topics or themes that are interesting to all members of a VLC, members share their special experiences, feelings and ideas, and they present explicitly their individual implicit knowledge by discussions, visualization, experiments, and trigger innovative thoughts in the process of interactions. In the externalization of individual knowledge, the implicit knowledge can be explained and externalized by metaphor, simulation, and can be formed into the conceptual knowledge after formalization.

Combination. If the new knowledge, which is scattered in notes of a learning/knowledge forum stored anywhere in the database of a VLC and is fragmented, messy and discrete after learners have discussed and interacted frequently, has not been summarized, ordered and combined according to certain rules or regulations such as meta-data, it is difficult for learners to find useful and needed knowledge in the database, therefore the expected goal of knowledge sharing and knowledge conversion cannot be easily achieved. Combination is a conversion process in which the concepts derived from above externalization are converted into a sorted knowledge system. Specifically put, for getting to the goal of managing knowledge, a VLC tries best to bind together the explicit knowledge from externalization and then to sort, adjust, categorize, and synthesize it, and next, to store it in the knowledge base in which learners can easily look for and retrieve what they need by any means, anywhere, and at any time. Moreover, this diffusion process of explicit knowledge can create newer and more systematized knowledge, and it is the implementation stage of converting individual knowledge into collective knowledge (Gan, 2005, p.164).

Internalization. The internalization of knowledge in essence is an active learning/training process. Only when the collective knowledge obtained from socialization, externalization and combination has been internalized into personal implicit knowledge, and then shaped into a sharing schema and skill does it become valuable assets and active (non-inert) knowledge. The internalization process transfers community explicit knowledge to the individual. Learners progressively accumulate and enrich their knowledge through internalization.

The above, four-way conversion model is a continual, extending and spirally progressive process in which individual learners continue to create new knowledge; and a VLC gradually accumulates explicit knowledge and progressively increases the volume of the knowledge base. On one hand, collective knowledge is converted to personal knowledge through deep dialogue and collective inquiry; on the other hand, personal learning problems are converted into public issues through community processing (group processing), and then personal problems are solved by way of collective knowledge. Thus it makes for a better circulation — speeding up individual learning and innovation in VLCs.

Knowledge Building and Zone of Proximal Development of a VLC

Knowledge building and Knowledge Building Processes in a VLC

"Knowledge building may be defined as the production and continual improvement of ideas of value to a community, through means that increase the likelihood that what the community accomplishes will be greater than the sum of individual contributions and part of broader cultural efforts" (Scardamalia & Bereiter, 2003a). The distinction between learning and knowledge building is that, just as Scardamalia and Bereiter (2003a) put, "learning is an internal, unobservable process that results in changes of belief, attitude, or skill; knowledge building, by contrast, results in the creation or modification of public knowledge." In knowledge building pedagogy, all ideas are treated as improvable, and idea improvement is its basic, explicit principles (Scardamalia, 2002). In knowledge building environment, community members continue to create new knowledge of value to the community and to enable further knowledge advances.

From the perspective of cognitive and intelligence development, and the trajectories of knowledge building in a VLC, the processes of knowledge building can be classified into four successive stages: sharing, negotiation, co-construction, and integration from the macro-analysis vision; and the cognitive behaviors of knowledge building can be classified into nine phases from the micro-vision (Gan, 2005, p.265) (see Table 1).

Table 1. Stages of knowledge building and collective wisdom advancement in a VLC

Cognitive behaviors	Stages/Descriptions
	Sharing
Question	Propose a question, opinion, idea or topic (well-structured/ill-structured); introduce a new concept; describe the origin, background, context, definition, purpose and intention of the question.
Explanation/Clarification	State a fact, concept and theory; explain an opinion; clarify the misunderstanding and blurring of meaning.
	Negotiation
Conflict	Cause contradiction; pose a substitute or different opinion and evidence.
Support	Support other's idea or standpoint, and expound it further with an example, experience, etc.; or improve other's idea.
Defense	Stick to the opinion of one's own; defend the preceding statement with a further interpretation and evidence.
	Co-construction
Evaluation	Verify a hypothesis or opinion; make an evaluation or judgment about a viewpoint, suggestion and plan.
Consensus building	Try to achieve an agreement or consistent understanding on a theme or problem-solving.
	Integration
Synthesis	Organize and integrate different ideas; make a generalization or summarization; draw out a consistent conclusion.
Reflection/Extension	Reflect on the problem-solving strategy, elicit a general rule; apply the rule to a new context.

Zone of Proximal Development of a VLC

The preceding successive stages—sharing, negotiation, co-construction, and integration—are four progressively rising processes with no definite boundary. Therefore it can be compared with the Zone of Proximal Development

(ZPD) (Vygotsky, 1978) and combined into the Zone of Proximal Development of a VLC (Gan, 2005, p.266) (See Figure 10).

Zone of Actual Development of a VLC. Although the learners in VLCs have individual differences just as discussed above and their zones of actual development are different from one another respectively, there are no big differences in the same VLC; otherwise, there is no base for common language and learning groundwork. It is the diversity they own that is necessary to share, discuss and debate in the VLC. This is a process of idea generating and idea sharing. Therefore the zone of actual development of a VLC can be compared to the stage of "sharing" in knowledge building.

Zone of Proximal Development of a VLC. This zone can be compared to the stages of "negotiation" and "co-construction" in knowledge building. By means of collaborative learning, learners complete meaning construction in the course of debating, arguing, rebutting, defending, assessing and judging different ideas. This is a process of negotiation and construction of meaning, and idea linking in which learners can attain higher levels of achievement than they can do in self-study.

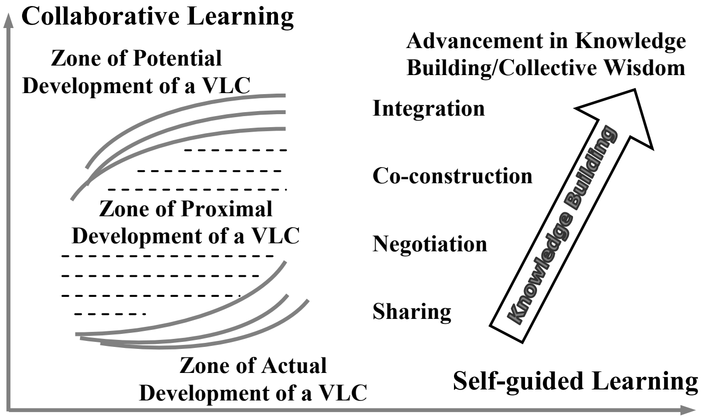

Figure 10. Zone of proximal development of a VLC

Table 2. Characteristics of knowledge building and collective wisdom advancement in VLCs

Convergent process	Communication process	Learning process	Learning outcome	Knowledge building stages	ZPD of VLCs
Divergent thinking (Idea generating)	Monologue	·Brainstorm (problem initiating)	·Diversified ideas ·Divergent or loosely linked state of personal ideas	*Sharing* ·Question ·Explanation /Clarification	Zone of actual development
Divergent to convergent thinking (Idea linking)	Dialogue	·Debate and negotiate ·Construct collectively (Problem solving)	·Personally deeper understanding, meaning negotiation and conceptual change ·Idea improvement ·Shared deep understanding ·Cognitive intelligence advancement	*Negotiation* ·Conflict ·Support ·Defense *Co-construction* ·Evaluation ·Consensus building	Zone of proximal development
Convergent thinking (Intellectual convergence)	Resonance	·Synthesize (Problem solved)	·Extending shared understanding ·Idea convergence ·Integration of collective wisdom ·Wisdom advancement	*Integration* ·Synthesis ·Reflection /Extension	Zone of potential development

Zone of Potential Development of a VLC. This zone can be compared to the stage of "integration" in knowledge building. If there are only idea divergence and idea linking and no idea convergence, there will be no knowledge building and the formation of new knowledge and collective wisdom. The integration is none other than the progressive process of convergence. Through the improvement, generation, summarization, induction and synthesis of ideas, and the reflection on problem-solving strategies and learning processes, learning in the whole VLC will move to a new and higher level. The outcome of these long-term practices inevitably leads to the advancement of learners' potential capabilities.

Summarization of Knowledge Building and Cognitive Behaviors in VLCs

It should be pointed out that knowledge building can not be completed for once. The four stages of knowledge building are processes of recurrence and spiral upgrade. The end of one circle is the start of another. Only after learners experience the long-term practices for recurrent circles can learners acquire knowledge building abilities and advance their mental models, moving collective wisdom to a higher level in a VLC. After analyzing the developmental trajectories of knowledge building and collective wisdom advancement, we can summarize the processes of communication, learning, and cognitive behaviors relevant to knowledge building and collective wisdom advancement (Gan, 2005, p.267) (see Table 2).

Conclusions

The aim of a VLC built on the theories of constructivism, situated learning, and knowledge building, etc., is to apply individual intelligence to learning, bring the advantages of collective wisdom into play; solve the difficult problems in independent learning; and lead to the integration and sublimation of collective wisdom through long-term interaction, collaboration and knowledge building. As a result, it is a necessary and viable way to construct a learning framework for knowledge building and collective wisdom advancement in VLCs from perspectives on systematic wholeness, intelligence wholeness and dynamics, learning models and knowledge management.

This study analyzes the knowledge building and collective wisdom advancement in a VLC from four dimensions:

- *Systematic Wholeness.* Unity and diversity are two important angles to analyze the participants' characteristics in a VLC. Unity is the essential base of building a VLC and diversity is a source of innovation.
- *Intelligence Wholeness and Intelligence Dynamics*. Collective wisdom is a system phenomenon. It is a continuum from individual multiple intelligences to collective wisdom. Thus the different stages and characteristics of intelligence wholeness and intelligence dynamics are completely analyzed.
- *Learning Models*. Independent/individualized learning and collaborative learning are two main learning models. A VLC is a most suitable environment for learners' practicing knowledge building collaboratively and actively and for advancing collective wisdom.
- *Knowledge Management*. Knowledge Management emphasizes knowledge sharing, the conversion between implicit knowledge and explicit knowledge, community of practice and knowledge innovation, it therefore provides an essential support for knowledge building, individual and collective wisdom advancement.

In the end, the zone of proximal development of a VLC and the processes of communication, learning and cognitive behaviors relevant to knowledge building and collective wisdom advancement are constructed and discussed based on a combination of Vygotsky's theory of the zone of proximal development and the trajectories of knowledge building.

The main work of this study is that it puts forward an integrated framework for knowledge building and collective wisdom advancement in VLCs, which is based on current theories and some research results in education, psychology, learning, cognitive science, knowledge management, and educational technology. The theoretical analysis applies these theories into a VLC environment and examines its characteristics from different perspectives for better understanding of the essence and processes of VLCs.

The main goal of this research is that the framework can offer a new viewpoint for looking at the different profiles of online learning and VLCs, allowing educators to think of ways of applying the principles of constructivism, situated learning, collaborative learning, knowledge building, collective intelligence and wisdom into online learning and

VLCs. Also, we wish this study could attract the educators' attention from distance education and stimulate some discussions on how to better integrate different theories and apply them into practice.

There are also some theoretical constraints and limitations on this framework:

Firstly, although some experiments were conducted on validating several main principles of knowledge building (Scardamalia, 2002; Lamon, Reeve, & Scardamalia, 2001; Gan, 2005, p.270-365) and idea divergence/convergence in a VLC (Gan, 2005, p.252-263), and some on the relations between student characteristics, cognitive and learning styles, and the effects of online learning (Anderson & Reed, 1998; Rasmussen & Davidson, 1998; Charlton & Birkett, 1999; Tolmie & Boyle, 2000; Wilson, 2000), which are close related to the unity and diversity in this framework. It is evident that the framework seems to be an ideal-typic model, but until now there are still lacking rich empirical and systematic evidence and experiments that can fully prove this framework from integrated perspectives. To lay a solid foundation for this framework, our main work in the future is to probe into the relationships of different components of the framework, to find out the weaknesses and revise them, and strengthen the theoretical foundation by conducting further fundamental experiments.

Secondly, although the framework has been brought forward, how to better integrate these theories into VLCs still needs to be further explored. Although there are, for example, some literatures on the merging of e-Learning and knowledge management (Barron, 2000; Marshall, B., et al., 2003; Vasilyeva, et al, 2005; Ubon & Kimble, 2002), and on the application of knowledge management into an online community of practice (Beinhauer, 2000; Kim, et al., 2003), the application of knowledge management into VLCs is still at an initial stage and needed to be further explored, and its effectiveness is also needed to be examined (Smits & Moor, 2004).

Thirdly, this study is development research. "Development research is often initiated for complex, innovative tasks for which only very few validated principles are available to structure and support the design and development model" (van den Akker, 1999). The aim is not to elaborate and implement complete interventions in the framework, but to come to (successive) prototypes that increasingly meet the new and innovative requirements. "The process is often cyclic or spiral: analysis, design, evaluation and revision activities are iterated until a satisfying balance between ideals and realization has been achieved" (van den Akker, 1999).

It should also be noted here that the emphasis on the importance of collective intelligence and collective wisdom in this study is not intended to belittle the role and importance of an individual mind and a compelling idea. Instead the processes of empowering and expanding collective intelligence and collective wisdom in VLCs can be used by individuals also, for example, to cope with a great deal of routine work so that he/she has more time, resource and support for creativity.

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The Crisis of Educational Technology, and the Prospect of Reinventing Education

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ABSTRACT

With the fading monopoly of the industrial mode of production and the emergence of the "information revolution," modern technology has pervaded almost every aspect of human life. In education, however, information technology has yet to find a place, despite the unceasing attempts to "fit" it into the existing educational system. The paper argues that the industrial mode of production was successful in inventing "education" as a new paradigm, institutionalizing it in schools, and implementing it through a number of tools, such as "certified" teachers, curricula, and textbooks. By contrast, the information mode of production has created the tools, namely "educational technology," before developing a corresponding paradigm or institution. This crisis of educational technology is therefore a corollary of its misplacement, and subsequent malfunction, in the still-in-use industrial paradigm and institution (education and school). The paper suggests that, in order to ensure a proper functionality of modern technology, we need to resolve this theoretical inadequacy. A possible solution would be to thoroughly restructure "education" and schools, as remnants of the industrial age, into a new paradigm and institution.

Keywords

Education, Educational technology, Paradigmatic conflict, Information age

Introduction

The widespread use of computers and telecommunications in the second half of the last century has caused fundamental changes in the character of modern societies. The ubiquity of computers and telecommunication devices in many areas of human activity and the increasingly important role of information as the main driving force of the post-industrial era have created a new mode of production and, to many, a new age. Often referred to as the Information Age, the current era is marked by a shift from the emphasis on producing and controlling material goods to controlling information (Negroponte, 1995). The current shift affects a range of issues from manipulating digital data with all the implications on human communication, perception, and understanding (Negroponte, 1995), conducting business (Tapscott, 1996), and relying more on services than on industrial production (Poole, 1995).

With the increasing availability and capability of computers, "computerization has risen to ideological prominence, an expression of grand hopes and ideals" (Winner, 1986: p. 595). Computers and their related technology have become associated particularly with the images of positive change and renewal (Watson, 1998). In education, however, the impact of computers and their related technologies has been minor. As Bennet (1999) notes, "The only important field that computers have failed to change significantly is education" (p. 46). Despite the huge expenditure, wide experimentation and research, and discursive enthusiasm, educational technology has failed to show substantial benefits to the field (Gentry & Csete, 1995; Bennet, 1999; Salomon, 2002). This has created a crisis in educational circles and generated a wide controversy among educators and scholars concerning the place of modern technology in education and the feasibility of the various attempts to fit it into the existing educational system (Stoll, 2000; Clark, 1994; Salomon, 2002).

Efforts to explain and subsequently resolve the crisis of educational technology have centered mainly on the material obstacles to the implementation of educational technology in schools: lack of planning, paucity of funds, shortage of hardware, absence of standards, inadequacy of teacher preparation, need of software updates, lack of computer expertise, lack of knowledge of how to apply technology in the classroom, insufficiency of access to computers, polarity of research, computer misuse, commercialized web content, digital divide, gender bias of technology, health issues, exposure to improper material, etc. (Stoll, 2000; Alliance for Childhood, 2001; Becker, 1998; Pelgrum, 2001; Earle, 2002). The paper seeks to demonstrate that the real causes of the crisis extend beyond these concrete problems to more theoretical issues related to the "identity" of educational technology, its theoretical assumptions, and its paradigmatic conflict with education. It suggests that understanding these theoretical underpinnings is an essential starting point for finding appropriate solutions to the current crisis. A comparison between the educational system in the industrial age and its counterpart in the information age might help in putting the crisis in perspective before considering its main causes and possible solutions.

Industrial Education

Education in its presence sense was completely unknown before the Reformation, except as that part of early upbringing that is common to all human beings (Illich, 1973). According to Illich (1973), education was different from instruction needed by the young; and from learning, which was informal and lifelong, i.e., people could learn from their environments and their own experiences; and even from study which required a tutor/scribe and dedication. Although "study" was the preferred method of knowledge advancement in particular fields (e.g., religion, philosophy, mathematics, etc.), all of the other knowledge patterns were viable for increasing people's knowledge of their environments and the world (Gulati, 2003). That is, no matter what the route to knowledge was, one can still be called knowledgeable based on his/her ingenuity, skill, and ability to resolve problems and answer questions that faced people in their daily lives.

The established knowledge patterns underwent a significant change under the industrial system, which was simultaneously changing its work and cultural patterns and promoting science as the ultimate means for understanding phenomena (Olson, 1974). The industrial system "re-invented" education and placed it at the top of the knowledge tree. Education came to indicate the process of internalizing, typically via dedicated study and learning and with the aid of instruction, a number of prescribed topics, attitudes and values arranged into curricula. Within this knowledge system of industrial management, students were situated at the receiving end of the "knowledge transmittal" process; they had no control over the content or the method of their "education" (Jones & Maloy, 1996; Berryman, 1993). The acquisition of the types of knowledge promoted through the new system became a necessary route for attaining other ends (positions, social status, well-being, etc.). Eventually, education became *the* new knowledge paradigm and sole legitimate way of knowing.

The creation of education as a paradigm was escorted by the founding of science-based schools, which departed *conceptually* from the common religious schooling of the time. This was a necessary step for institutionalizing the new paradigm. John Amos Comenius, a Moravian bishop of the seventeenth century, was one of the founders of the modern school within which the education paradigm operated (Piaget, 1993; Illich, 1973). In *Great Didactic* (*Magna Didactica)*, Comenius maintained that education is an inevitable route to help children attain full humanity and that schools should be the context of this educational process. Further, he advocated a science of education that would take a step-by-step approach to learning. Schools would refine raw elements (i.e., students) by graduating their spirits through stages of enlightenment, "teach everybody everything," and eventually enable everyone to become a functional member of society (Illich, 1973). Through his approach, Comenius did not simply make an outline for the assembly-line production of knowledge, but also solidified a theory of mass production in educational terms. Education became a mechanism that would bring forth "a new type of man who would fit into an [industrial] environment created by scientific magic" (Illich, 1973: p. 19).

Not only did the industrial mode of production succeed in creating a new paradigm and in institutionalizing it, but it also created the tools needed to run it. Hence was the invention of "certified" teachers, curricula, textbooks, tests, and so on. With these developments, a whole knowledge system was primed to attain the ends set forth by the industrial society. The knowledge system was a means for an end; it was a means for legitimizing the industrial mode of production, for indoctrinating people into this mode, and for preparing people to serve the assembly line. On the other hand, the new knowledge system helped de-legitimize the agricultural mode of production and simultaneously create the myth of science as a meta-narrative and a substitute to metaphysics, which was then labeled "superstition."

With the paradigm shift and the subsequent establishment of schools, the industrial mode of production did not merely form a new knowledge system, but also created a new society and new men. As Rorty (1989) suggests, "Changing languages…may produce human beings of a sort that had never before existed" (p.7). Knowledge came to mean the amount of schooling one received. The redefinition of knowledge as schooling made education seem necessary, thus compounding "the poverty of the unschooled with discrimination against the uneducated" (Illich, 1973, p. 19). People who have climbed up the schooling ladder were also climbing the socioeconomic ladder. People who had a higher level of education were entitled to decision-making and management positions, whereas the assembly line jobs were relegated to those with elementary-level education (Welker, 1991). Those who had no schooling were labeled ignorant, backward, stupid or at best "uneducated." Licenses, certificates, diplomas became the "emblems" of knowledge. A certified physician, for example, would be called a doctor, while a non-certified one would be called a quack, even when the latter knew more about the field than the former. By accepting the authority of the school agency to define and measure their level of knowledge, people were under the mercy of other industrial agencies that defined for them their level of fitness into the society (Illich, 1973). Once people came to believe in the value of the "knowledge stock" they acquired in school, education became the measure of success, income levels, well-being, social class, and so on (Welker, 1991).

The development of education into a full functional social structure allowed the industrial system to redefine institutions, patterns of behavior, expectations, and contexts of power exercise. Together with schools, education became a perfect means for streamlining people and regulating them according to the ideals of the industrial society (e.g., more goods equals well-being, health, etc). This pattern of mass production education served the purposes of the industrial society till the first half of the twentieth century. By the mid 1950s, the information revolution was underway (Toffler, 1980), coinciding with widely reverberating calls for educational reform (although similar but less fervent calls existed since the break of the twentieth century) (Besser, 1993).

Information Age and the crisis in education

Historically, the information age was envisaged a long time before computers ever existed. Arguably, Jorge Borges' playful description of a "labyrinth of symbols… a book which had the possibility of continuing indefinitely" (1941: p.33) and Vannevar Bush's notion of a "future device for individual use, which is a sort of mechanized private file and library" (1945: p. 45) pioneered the earliest visions of the current networked computers and put the information age on track. However, Borges's book-garden-maze and Bush's desk-library-machine had less to do with the "physical" computer and much more with "a change in how our minds are working" (Murray, 2003: p.3). In other words, those two thinkers had envisaged a new paradigm and possibly a new social order away from the prevailing industrial social structure.

Unfortunately, later developments in the computer industry took on a totally physical form with no corresponding paradigmatic developments, that is, with little change in how people envision and practice their social lives. The field of education, in particular, has remained theoretically unaffected by the introduction of the digital media despite the proliferation of computers in schools and in society at large. In fact, the advent of the new media has not merely failed to produce any tangible changes but also engendered tensions in the established educational system. A quick overview of the rise of electronic technology might help delineate its current problematic situation in schools.

The idea of using computers in education goes back to the mid 1950s as the winds of reform were surrounding the educational enterprise in the United States (Poole, 1995). First sponsored and then further propelled by the military-corporate complex (Besser, 1993), the thrust toward technologizing schools and the related reform thereupon originated partly in the information industry's quest to legitimize itself through a knowledge system, to "program" people in this system, and to produce people who would serve its industry. Early computers found their way into American education through the early projects of IBM, which were attended by a wide optimistic belief that such a machine "could be programmed to handle almost any problem demanded of it" (Poole, 1995: p. 42). As the information revolution gained momentum and computers showed greater potential in various human realms, it was suggested that the new technologies would revolutionize education just as they revolutionized industry (Fouts, 2000).

The notion of "revolutionizing" the existing educational patterns was quite explicable, given the promise of the new technologies to democratize learning, to decentralize instruction, to increase access to multiple information resources, to remove hierarchies in communication and interaction, to enhance students' collaboration and exploration, and to obliterate the stringent structure of the classroom (Poole, 1995; Olson, 1974; Warschauer & Healey, 1998). In educational thought, the realization of this vision has remained indefinite. The strong belief that the electronic technology is of profound significance to education was debilitated by the absence of "information revolution" in educational terms. In fact, the vision fell short of its projection when the early behaviorist computer programs were developed partly to cure the ills of the "traditional" classroom and were eventually implemented "with the belief that they could convey information (and hopefully understanding) more effectively than teachers"

(Jonassen, et al., 2003, pp. iii-iv). Thus, instead of being used to explore new learning and teaching possibilities, the early computers were used to make existing practices more efficient. Under the behaviorist model, computers were in control of the learning process; they “present and store information, motivate and reward learners, diagnose and prescribe, provide drill and practice, and individualize instruction” (Tolman and Allred, 1991, p.5). The content of education remained the same in nature for all disciplines; “educational software was mostly textbooks presented in electronic print formats” (Valdez, et. Al., 2000). Relatively little emphasis was put on the learner, who was usually viewed as a passive recipient of instruction. In effect, the new model replicated the industrial learning patterns, with a single difference in the medium of instruction: a computer versus teacher. Fortunately, it did not take many educators long to discover that a mere change in the medium of instruction does not influence students’ learning or class dynamics. Critics suggested that behavioral-based computing “took the control of learning out of the hands of the teacher and placed it into the hands of the computer software programmer” (Valdez et al, 2000), dehumanized the learning process (Thompson et al, 1992), and ignored the “learner satisfaction, self-worth, creativity, and social values” (Alessi & Trollip, 2001: p. 37). In response, technological apologists claimed that the current uses of the technology did not exploit the power of the computer, and hence was their low quality (Jonassen, 1988, Striebel, 1986).

The early 1980s witnessed an ostensible shift in the functionality of computers and their related technologies in schools; “behaviorist and systems theoretic models and their products (drill programs, tutorials, computer managed instruction) began to give way to principles for designing “learning environments” and “cognitive tools” which make full use of advanced computer based technologies in support of knowledge construction” (Damarin, 1998: p.3). The shift was instigated by the spread of microcomputers, the concurrent improvement in computer power—a technical development that lacked any corresponding theoretical advancement—, and the “re-discovery” of Cognitivism and Constructivism as learning theories well suited for computer-mediated learning environments. Cognitive science perceived learning as interactive rather than reactive and shifted the focus of instructional technology from "procedures for manipulating instructional materials to procedures for facilitating learner processing and interaction" (Saettler, 1990, p. 318). Constructivism emphasized the importance of knowledge construction through action, exploration, discovery, and collaboration and in meaningful learning environments (Gärdenfors and Johansson, 2005). The advances in the power and accessibly of microcomputers allowed for the development of instructional material and software that were based on the principles on cognitive and constructivist learning theories. However, the few cognitivist/constructivist computer-based activities supported through these programs were of limited use/value to the classroom because they needed extended class time to complete (Wyatt, 1987). Besides, they embodied an add-on to a central curriculum (Adams, Morrison & Reedy, 1968) and eventually failed to significantly restructure the established learning environments. By the late 1980s and early 1990s, educational technology came under fire for the computer was still being used in an improvised and disconnected fashion and thus "finds itself making a greater contribution to marginal rather than central elements" of the learning process (Kenning & Kenning, 1990, p. 90). In sum, the bond between cognitivism/constructivism and the digital media did not introduce a real change into education; rather, it was an attempt to rework another component from the exiting educational system, namely, methods of instruction and learning. At this point, many educators predicted that the “media will never influence learning” (Clark, 1994); the “computer will be just another in a series of highly touted technological tools that have neither revolutionized learning nor lived up to initial promises" (Dunkel, 1987: p. 254).

In the 1990s-plus years, educational reform took on a different direction upon the emergence of the Internet and the World Wide Web. The internet was hyped as “a means of bringing the outside world into the classroom, while connecting students to resources hitherto unimagined” (Trend, 2001: p. 68). The transformational capabilities of the Internet for communication, information access and collaboration eventually triggered calls for transforming the curriculum, fitting certain technological applications into the existing curriculum, and even fitting the curriculum to the computer (Earle, 2002). To many observers, however, web-based learning experiences reflect a quantitative increase in information accessibility and availability, rather than a qualitative change in the curriculum (Fullan, 2000; Earle, 2002). Moreover, the majority of web-based applications have not relied on any type of theoretical rationale for their incorporation into the curriculum except for the theoretical framework already built into basic web exercises (Salaberry, 2001). More importantly, while a number of web applications were found educationally relevant, few accompanying changes occurred in the other parameters of the industrial classroom. Given these limitations, the effect of the Internet on the classroom floor has remained virtually imperceptible.

It is no wonder then that the grandiose expectations about the revolutionary role that computerization is going to play in education are now on the wane. After thirty years of experimentation and research in educational technology, little has been found about its benefits to education (Hirvela, 1988; Clark, 1994; Thompson et al., 1992; Gentry & Csete, 1995; Watson, 1998; Stoll, 2000). This explains the fact that educational reform started with books, chalkboards, and teachers at the head of the class and ended up with the same tools. As Gärdenfors and Johansson (2005) note:

> Some years ago, there was a tendency to believe that if one could only install enough computers in the school, many educational problems would be solved. However, students as well as teachers are to an increasing extent questioning the value of information technology in education. Even if computers are frequently used for word processing, information search, email, and chatting, the worry is whether these tools really improve how students learn (p.1).

Obviously, the problem does not reside in electronic technology itself, but rather with its uneasy and traumatized entry into the classroom. Heeding this problem, Baker (1981) maintains that "a significant factor is that they [computer-based systems] are out of context…Although such systems may be perfectly rational when considered in isolation, they do not fit within the framework of the existing instructional scheme of things" (P. 23). Having been integrated within a system that was created for control and manipulation, educational technology has lost much of its transformative potential.

Explaining the Crisis

Apparently, the cut-and-paste approach underlying the introduction of electronic technology into the classroom suffers from major theoretical deficiencies. Educational technology is the product of the same forces that nurtured the computer culture and gave shape for the information age. These forces, represented mainly by corporations, universities, and the computer industry (Kearsley, 2002), have promoted the revolutionary and reformist role of computers and envisioned a new learning environment that is healthier and more efficient than the industrial educational system (De Castell, Bryson, & Jenson, 2001). However, the advocacy for educational technology has remained bounded by the antinomy of strong beliefs in the power of the new technology to substantially revolutionize education and by the absence of a matching paradigm and institution within which modern technology can operate. Unlike the industrial system, the information mode of production developed modern technology as a stand-alone tool before a corresponding knowledge paradigm or an institution have been established—a flaw that might be caused by the misinterpretation of Borges' and Bush's visions of the new technology. This paradigmatic void is the root of the crisis of educational technology, and it is responsible for the repercussions of its integration into the industrial paradigm, i.e., education.

With the absence of a matching paradigm to host the new media, electronic technology was mapped onto education, and efforts followed to "fit" it into the industrial paradigm. These efforts, however, have been impeded by the substantial disparity between the assumptions of electronic technology and those of education. On the one hand, electronic technologies seek to democratize learning, to decentralize instruction, to reorganize instructional material, to increase access to multiple information resources, to remove hierarchies in communication and interaction, to enhance students' collaboration and exploration, and to obliterate the stringent structure of the classroom (Warschauer & Healey, 1998; Poole, 1995; Olson, 1974). On the other hand, the educational system rests on such assumptions as top-down management, teacher control, textbook authority, hierarchy, competitiveness, individualism, structured classroom, linearly structured activities, discipline, lecturing, knowledge banking, uniformity, locality, and face-to-face interactivity (Welker, 1991; Jones & Maloy, 1996). Such disparity in assumptions exhibits the uncomplimentary relationship between the two and foreshadows the tense integration of the former into the latter.

A feasible scheme for introducing the information-age tool into the industrial paradigm has necessitated a reconfiguration of the role of the digital media; educational technology came to be perceived as "aids" to instruction (Olson, 1974) rather than a way to supersede the existing educational practices. The function of the new media is primarily to provide more effective means for conveying the kinds of information evolved in the last four hundred years, rather than to represent new experiences in ways that reflect the information-age culture. In effect, educational technology was re-oriented to serve the existing educational system, thus relinquishing the assumptions upon which its supposed revolution was based. Salomon (2002) refers to this as a Technological Paradox that results from:

> The consistent tendency of the education system to preserve itself and its practices by the assimilation of new technologies into existing instructional practices. Technology becomes "domesticated"…it is

> allowed to do precisely that which fits into the prevailing educational philosophy of cultural transmission and training for the world of yesterday (pp. 71-72).

Thus, instead of revolutionizing the educational system, educational technology has essentially reinforced the existing educational practices. This explains the fact that little change has occurred in education as a result of the introduction of the digital media.

But even with its new "compliant" role, educational technology has lacked a supporting theory of learning that would provide the theoretical rationale for its operation within the educational system (De Castell, Bryson, & Jenson, 2001; Salaberry, 2001). With the absence of such a theory and yet the impossibility of having educational technology operate in a theoretical vacuum, efforts have centered on pairing the digital media to existing learning theories, such as constructivism and behaviorism, which do not particularly tone with electronic technology or address information-age learning environments. Behaviorism, for example, is an artifact of the industrial thinking; it considers learning as a reactive process and individuals as "machines" that respond to conditioning (Clark & Salomon, 1986). Behaviorism represents "learning without understanding, teacher-centered lecturer with scant opportunities for curiosity and individuality, passive students, reductionistic, and conforming, that is, everything one wants to avoid in modern schools" (Gärdenfors and Johansson, 2005: pp. 4-5). In short, the behaviorist framework is unsuitable for the digital media because of their almost contradictory views to learning and learners. Unlike behaviorism, the constructivist theory shares many assumptions about learning with the digital media; nonetheless, its alliance with the electronic technology was complicated by the theory's vague conceptualization of "knowledge construction": what are students constructing, and how well, how useful, and how deep are these constructions? (Gärdenfors and Johansson, 2005). This inadequacy has further blurred the mission of electronic technology in education and brought to light the failure of the information mode of production to develop a learning theory of its own. As Gärdenfors and Johansson note, educational technology still lacks a unifying theory of learning that would serve as a foundation for its use in the classroom.

These theoretical failings on the part of the information mode of production have been aggravated by the resistance of key actors in the industrial educational system to adopt the new tools. Whereas the change staged through educational technology has been pushed by forces that are external to the educational enterprise, internal elements in the educational system are resisting this drive (De Castell, Bryson, & Jenson, 2001; Marshall and Ruohonen, 1998). For one thing, education has been part of human consciousness for so long and its values have been readily imbibed by those involved in the field. A well-known psychologist and educator, Sarason (1982, cited in Jones & Maloy, 1996) acknowledges: "Today we support this effort at educational change, tomorrow that one, or we may do both at the same time, but when we see that the more things seem to change the more they seem to remain the same, we direct blame outward because we cannot entertain the possibility that we, and those we blame, have basically the same conception of what schools are and should be" (p. 21). This conceptual incapability to change has theoretical grounds in the indoctrination of the industrial paradigm. For example, teachers' resistance to the change that computer technologies may bring into their teaching practices is a phenomenon well documented in educational research (Watson, 1998; Ridgeway and Passey, 1995; Pelgrum, 2001). Watson (1999) reports Willis (1992) asking "why do some teachers, when faced with an opportunity to begin using technology in the classroom, treat it more like a disease to be avoided than a promising aid to effective instruction" (p. 190). In fact, teachers feel uneasy about the computers' challenge to the values and roles set up for them by the industrial paradigm. Hence is the contention that "teachers tend to teach the way they are taught" (Dils, 2004). It might be said that teachers' challenge to the digital media is but an incident of the resistance of the industrial paradigm to modify its setup or functionality.

Indeed, the above theoretical tensions, as a corollary of the lack of a knowledge paradigm and institution congruent with information age, lie at the heart of the current crisis of educational technology. The malfunction of the information media within the present educational structure is the manifestation of this problem.

Conclusion and Implications

As the above overview demonstrates, the "technological revolution" in schools has been beset by theoretical inadequacies that have kept educational technology at the margins of the established educational system. As Jones and Maloy (1996) argue, "In the struggle for a computer revolution in schools, "the classroom wins for now"" (p.282). Unfortunately, technology's lack of impact on day-to-day classroom practices has been "construed as an implementation failure, or as resulting from a temperamental shortcoming on the part of teachers or technologists" (Hodas, 1993: p.1). Efforts to resolve the crisis of educational technology have centered on overcoming these material obstacles, thus overlooking the theoretical side of the integration process. No wonder that most of the models proposed to resolve the crisis have met with little success. Gentry and Csete (1995) note that:

> Efforts to set up prototype educational systems that can demonstrate the power of restructured educational environments in concert with the best of educational technology have not been successful, despite the many schemes proposed by many authors (p.21).

Though valuable and necessary, these efforts have a narrow sight of the scope of problems surrounding educational technology.

What is needed then is a conceptual shift in emphasis from the tangible barriers of the implementation process to more theoretical issues related to the identity of educational technology, its theoretical assumptions, and its paradigmatic conflict with education. Such a shift implicates a fresh vision of educational technology as an artifact of the information age that is extraneous to the industrial paradigm. Because of their different assumptions about the knowledge-acquisition process and because paradigms—and, by extension, their essential elements— cannot coexist (Kuhn, 1962), the digital media and education may neither work together nor attain a common goal. Hence, a resolution for evading education's present crisis starts out from choosing one of two options: (1) leave education and schools *untouched*, or (2) avail the potential of the new technology after thoroughly restructuring education and schools, as remnants of the industrial age, into a new paradigm and institution. While both options are possible and viable at this point, the increased presence of technology in schools and society at large will eventually make the second option inevitable. In that case, technological theorists need to initiate a shift from "education" to a new paradigm.

A paradigm shift begins with fresh reflections on new ways of considering social institutions and structures (Paul & Ward, 1995). Since paradigmatic shifts are revolutionary by nature (Kuhn, 1962), the new paradigm should not simply extend the models hitherto proposed to modify, renovate, or enhance specific elements in the educational system— all of which share their inability to move beyond the orbit of the industrial paradigm. Rather, it should depart altogether from the concept of education as a filtering and control system and reconcile with the vocational and cultural patterns of the information age. Eventually, such a move will necessitate the "reinvention" of education and schools and the transformation of other constituents of the industrial classroom, such as textbooks, curricula, and tests. The formation of such a paradigm will expectedly resolve the current crisis of educational technology and provide a framework for its proper functionality in the information age.

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Towards a methodology for educational modelling: a case in educational assessment

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ABSTRACT

Educational modelling is the modelling of educational [sub-] systems. Such a model is a framework containing important concepts, processes and relations. Several models have been published but their development, which we call educational modelling, still is a tedious process. We lack clear guidelines or a methodology. In this article we present a case study in which we take first steps towards the development of a methodology for educational modelling. We do so by analysing our current practice that we typify as expert-driven, model-centred and consensus-based. We explicate the assumptions under this approach and investigate whether these assumptions are explicit and confirmed by our case study. The results give rise to a number of guidelines that can be used by future projects and that provide a first step towards a more systematic approach to educational modelling.

Keywords

Educational modelling, interoperability of educational [sub-] systems, educational ontologies, case study

Introduction

Educational modelling refers to the modelling of educational systems or sub-systems, such as instructional design or assessment. Such a model is a framework that contains important concepts, processes and relations. Instructional design, for example, is modelled in Educational Modelling Language (EML) (see Koper, 2001) and IMS Learning Design (IMS Global Learning Consortium Inc., 2003). Tattersall et al. (2003) present a curriculum model used to help students navigate a curriculum. Hermans et al. (2005) developed a model for educational assessment, described and compared to other models in Joosten – ten Brinke et al. (in press).

Educational modelling can be seen as the building of an ontology – an interrelated collection of entities and their relationships. Although educational modelling is a highly specialized field within educational technology, its products may have a wide-reaching impact through consortia such as IMS and IEEE that foster the development of interoperability specifications and standards in education. Interoperability of an educational system like instructional design or assessment requires a model of the system in question. There still is a lot of work to be done in this field of which the results (i.e., open standards to increase interoperability) have a significant impact.

Several languages have been developed to support the development of ontologies. For example, the OWL Web Ontology Language (W3C, 2004) formally describes the meaning of terminology used in web documents. It was designed to meet the need for a language that facilitates the machine readability of (semantic) web content. A second example is the Unified Modelling Language (UML) (see Booch, Jacobson & Rumbaugh, 1998), which is frequently used as a notation language for a domain or conceptual model in a broad spectrum of software development for which it was originally designed.

Although we now have gained considerable experience in creating educational models, their formulation tends to be a tedious and time-consuming process (Hermans, van den Berg, Vogten, Brouns & Verhooren, 2002). There is a need for guidelines, or a methodology, that helps to build these models in a more efficient way.

The type of methodology that we are looking for combines elements of software and knowledge engineering. Methodologies that cover only one of these domains will not suffice as it may lead to an deficient ontology. Consider, for example, the Unified Process (Jacobson, Booch & Rumbaugh 1999). This is a software development methodology that uses the UML notations that are being used in educational modelling. Thus, UP seems a likely candidate to consider. Its strength is in modelling information and process flows (Abdullah, Benest, Evans & Kimble, 2002) and that is what we need to develop further instrumentation. However, our prime interest lies in the development of a domain model (or ontology), meaning a depiction of the concepts of a domain and the interrelations between them. Here, however, UP only offers some weak heuristics. Knowledge engineering methodologies, on the other hand, offer more support to stipulate domain knowledge. They tend to emphasize the procedural aspects of knowledge, rather than the declarative knowledge represented in a domain model. Thus, using only one type of development methodology may cause to overlook certain types of knowledge categories or the relationship(s) between concepts. This would lead to a deficiency in our ontology for we both need concepts and the interrelations between them.

Further, use-case modelling may be adopted in educational modelling. As Arlow & Neustadt (2002) point out, a use-case is a "*description of a sequence of actions that a system performs to yield value to a user*" (p.15). Modelling and collecting use-cases has proven useful in other instances of educational modelling (for example, see Manderveld, van den Berg, Hermans, Koper & Brouns, 2001; Gorissen & Tattersall, 2005). The work reported here, however, addresses a preceding stage in which a domain model is construed independently from services provided by a system.

The current practice in educational modelling combines knowledge elicitation techniques with UML modelling and is performed more or less ad lib depending upon the context in which the modelling takes place. This does not automatically lead to efficient modelling. A set of guidelines that structure the modelling process will greatly enhance the modelling. Therefore a case study was prepared as part of a joint project of the Open University of the Netherlands and the Central Institute for Test Development (CITO). This project aimed to define a model of educational assessment to '*provide insight into gaps between the different specifications to support assessment exchange initiatives*' (Joosten- ten Brinke et al. (submitted)). The major gap identified refers to the QTI interoperability specification (IMS, 2006) that is effectively limited to "classical" multiple-choice assessments and variations thereof. To create more advanced learning environments one needs more advanced assessment types. Other specifications do not fulfil this need because they are either specifically directed at the (technical aspects of) portfolio assessment (IMS ePortfolio (2005); IMS Rubric (2005), IMS Learner Information Package (2005)) or make use of QTI, such as IMS LD (2003). More information on the model can be found in this article under the heading "Modelling in UML" and in Joosten- ten Brinke et al. (in press).

In the case study data were collected to improve our understanding of current practice in educational modelling. The case study is limited to the initial phase of the project, during which a domain model for educational assessment was construed in a series of expert meetings.

Case characteristics and assumptions

As a first step towards a methodology, we concentrate on a number of general characteristics of our current practice in modelling, and in particular on the assumptions underlying these characteristics. If these assumptions are not met, any methodology based on them is likely to fail in educational modelling.

The first characteristic is that of the *expert-driven* nature of the sessions, in terms of content as well as the organization of the meetings. Experts acted as the source for the domain objects and relations to be used in the model. Furthermore, they defined the goals and procedures for each session. As an alternative, one could have chosen to limit the role of the experts to providing knowledge for the construction of the model and, eventually, evaluating the model.

To ensure that the domain of educational assessment would be covered as complete as possible a deliberate selection of multiple experts was made to cover various levels of education and a wide variety of assessment types. First experts from CITO were invited to the project. CITO is the leading testing and assessment institute in the Netherlands. CITO's main focus is on primary and secondary education but its services are also used in vocational education, higher education, adult education, government and trade & industry. Second assessment experts from Fontys University of Applied Sciences were invited. Fontys offers several higher professional education programmes and is working with innovative assessment strategies. In conclusion, assessment experts from the Educational Technology Expertise Center (OTEC) were chosen because of their experience with various assessment types in higher distance education.

The experts who contributed to the project also covered various expertise areas within assessment, such as measurement theory , item and test construction and validations, deployment of various assessment types, et cetera. In using these experts we expected that coverage and quality of a wide gamut of information could be guaranteed (McGraw et al., 1989). Moreover multiple experts may help to identify and solve differences in, for example, terminology and importance of concepts by discussion. During each meeting, topics to be included in the model were identified and prioritised by the experts. This way an agenda for topics to be discussed was determined. The agenda was guarded by two moderators to prevent topics to be left unspoken.

Second, the sessions were *model-centred*, i.e., all activities were directed towards further development of the educational model. During the sessions the objects and relations that the experts identified were cast 'on the fly' in UML diagrams. Experts were to validate these initial diagrams. An alternative approach would, for example, separate knowledge elicitation and modelling.

Finally, the procedures during the sessions were *consensus-based*. Participants, in particular the experts, had to agree about the procedures as well as about the content of the model. Here an important alternative to consider is whether all work has to be done in *one* team of experts.

In this case study we concentrate on the assumptions associated with the characteristics mentioned and test whether these assumptions were met in the case. For example, the expert-driven approach assumes that experts can define and maintain the overall goals of the project, as well as the goals of the individual sessions. It also assumes that experts can and will express their knowledge. The model-centred approach assumes that experts can translate their knowledge to the UML notations and test the models presented to them against their knowledge. The consensus-based approach assumes that experts can and will collaborate and reach consensus about procedures as well as about the content of the model. Before we present the data collected to test these hypotheses, we describe the case in somewhat more detail.

Case description

Team composition

The team for the project consisted of ten participants. Six assessment experts participated in eight expert sessions. Their task was to identify the building blocks of assessment and their relations. The experts came from three different institutions. They were selected to strike a balance between theory and practice. All experts had more than five years experience in assessment and they all were still active in the field, thus they would allow to capture state of the art knowledge.

Two moderators facilitated the sessions. They were experienced in moderating groups and both were knowledgeable in the educational assessment, although not at an expert level. A modeller, who had experience in modelling of ICT systems, took the lead in all technical UML modelling activities. Finally, a scribe was added to the team to record session notes and to collect evaluative data. Pictures were taken from the result of concept mapping exercises and from writings on the blackboard and flip-over.

Structure and work formats of the expert sessions

During the first session, the dates for seven subsequent experts sessions were planned over a period of two and a half months. Later on, it was decided to use the eighth session as a debriefing session.

Since no firmly established methods for educational modelling are available, the choice of appropriate methods was based on available literature on knowledge elicitation. Cooke (1994) provides an extensive overview of knowledge elicitation techniques discusses their strengths, weaknesses and application across different fields ranging from psychology to business management. She divides the methods into three families called (1) "observations and interviews", (2) "process tracing" and (3) "conceptual techniques". The latter contain knowledge elicitation techniques that result in representations of domain concepts, their structure and interrelations. Following McGraw and Harbison-Briggs (1989), Cooke recommends using a combination of techniques to minimize errors and to maximize the scope of domain coverage. In order to elicit declarative knowledge, she recommends concept brainstorming, free association, concept listing and (hierarchical) concept clustering. These then were techniques suggested to the experts. In the first session these techniques were used to formulate a first domain demarcation. Hierarchical concept clustering was then used to create and order ten topics that were scheduled for discussion and modelling in the next sessions. In this way, the experts defined the core agenda for the sessions (this agenda was dropped in the second session however). Note that only concepts and relations brought forward by the experts were included in the model. No background literature or models were incorporated by reference alone, emphasizing the expert-driven nature of the work methods used.

The techniques of brainstorming, free association, concept listing and hierarchical clustering were used throughout the sessions. It was assumed that using these techniques the experts would manage to reach consensus. If, however, no consensus would be reached within the time allotted, the moderators and the experts would make a joint decision on whether or not to stick to the agenda.

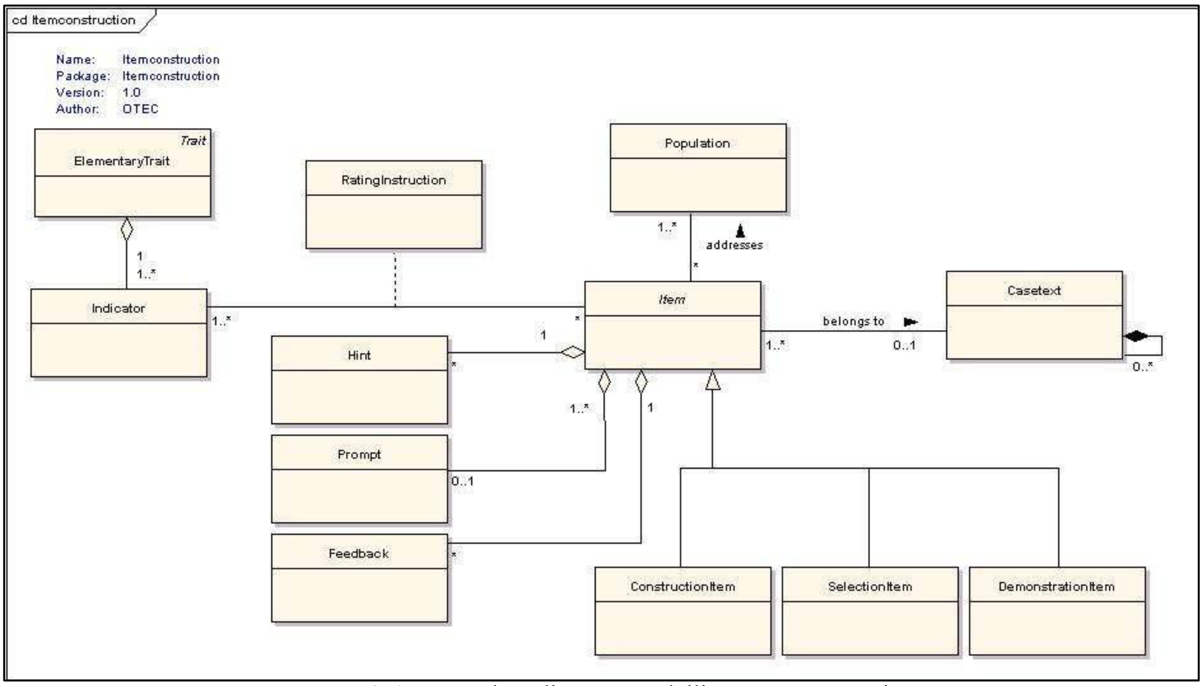

Figure 1. A UML class diagram modelling Itemconstruction

Modelling in UML

UML class diagrams (see Arlow & Neustadt, 2002 for an overview of UML diagrams) were used to model the different classes of objects and their relations in the assessment domain that the experts identified. The model consists of sub models, each depicting a different stage in the assessment process. The first sub-model is *Assessment design*, which describes the initial stage of assessment by stating the reasons for using assessment as well as different assessment types, a description of the assessment policy, an assessment plan, and so on . This is followed by *Item construction* which is built upon the definition of an elementary trait to be assessed and indicators to give evidence for this trait. Third, *Assessment construction* may take place. The central element here is a unit of assessment (UoA) that contains a unit of assessment definition, an assessment type and different items.

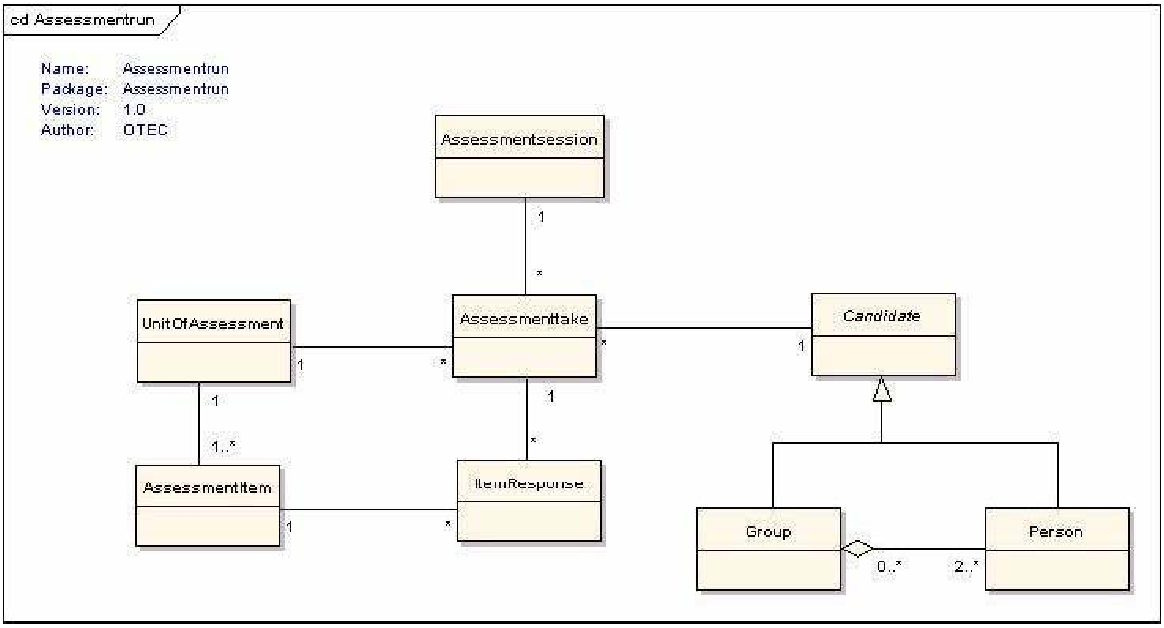

Figure 2. A UML class diagram modelling Assessmentrun

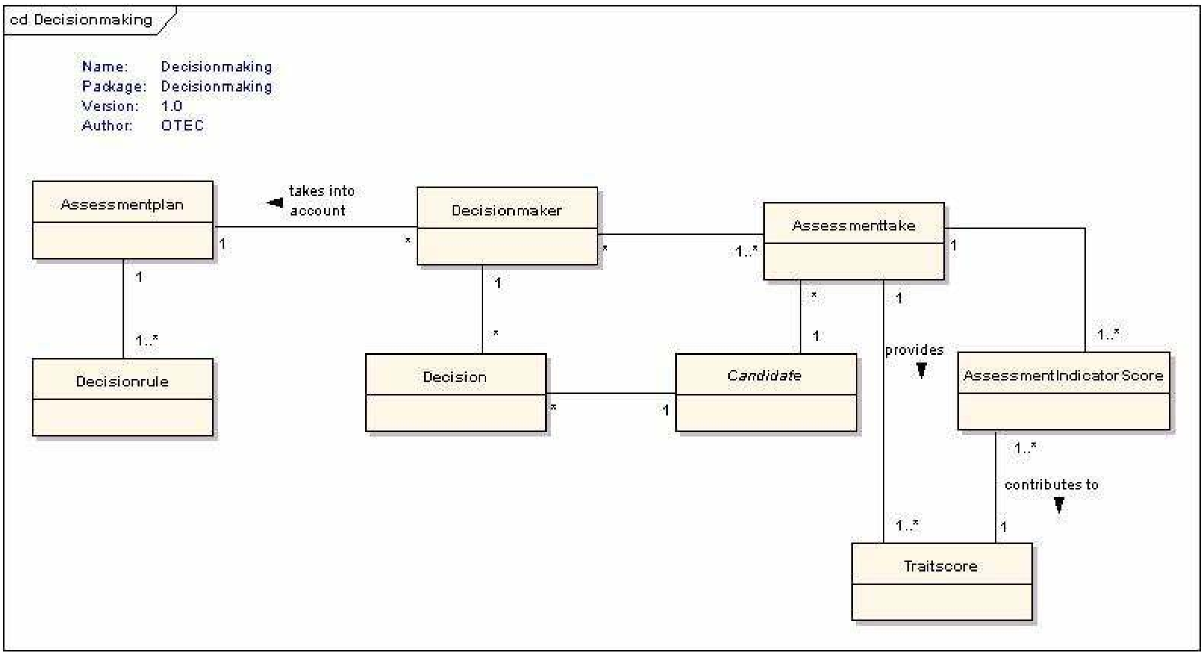

Figure 3. A UML class diagram modelling Decision making

To allow delivery of the assessment to the candidate an *Assessment run* is needed which presents a description of the candidates, sessions, and the output in the form of item responses. Processing of the results is taken care of by *Response rating* which contains the definition of rubric scores, indicator scores and trait scores. Finally, the scores are interpreted during the process of *Decision making.* Examples of classes are candidate, decision rules and the decision.. As an example, three sub models are depicted below. For the complete model we refer to Hermans et al. (2005) and the description in Joosten-ten Brinke et al. (submitted). The model can be downloaded at http://hdl.handle.net/1820/308.

One of the characteristics of the approach is *on-the-fly* UML modelling. The experts' input would be translated immediately into a tentative UML model that the experts would then discuss and amend whenever they felt that was necessary. In between sessions, the UML modeller would further refine the amended, provisional model into a complete (though partial) UML class diagram. This version would be presented to the experts at the start of the next session for final comments and adaptations.

In order to participate in this modelling process, the experts had to be able to comprehend basic diagrams in UML and to perform basic modelling activities. To that end they received a brief introduction to the concepts of UML class diagrams during the first session. *On-the-fly* modelling turned out to be very tedious and was replaced by modelling outside the expert session and the expert session was then used as a panel to evaluate the model.

Method

The investigation reported here is directed at the assumptions underlying the expert-driven, model-centred and consensus-based methods applied in this (and previous) cases. Associated with the expert-driven methods are assumptions regarding the organization of the sessions, and the domain knowledge brought forward during these sessions. It is assumed that (1) the experts can help organize the sessions, that is, they can define, understand and maintain the overall goal as well as the session goals (keep the agenda). As far as the domain knowledge of the experts is concerned, it is assumed that (2) experts can and will express their knowledge of the domain; (3) this knowledge is state of the art; (4) this knowledge is correct and sufficient to create an educational model of the domain, thus excluding the need to use other sources.

Associated with *model-centred* methods are assumptions related to the use of the notations of the models in the sessions. In this case, it is assumed that experts (5) can read and understand basic UML notations, and (6) can translate their knowledge into a UML notation.

Assumptions associated with consensus-based methods are that experts can reach agreements on (7) the organizational matters discussed above; (8) the objects and relations in the domain, and (9) on a UML model for the domain. Finally, it was assumed that (10) using UML would improve consensus building, because it would offer an unambiguous representation of the domain, in contrast to natural language.

Not all assumptions enumerated above were probed. In particular no assumptions have been tested that relate to the domain knowledge of the experts (assumptions 2, 3 and 4). These assumptions were addressed in subsequent phases of the project where the model was tested against on assessment scenarios and models.

Data were gathered at different times during the process: (a) session minutes were made, (b) after each session a questionnaire was administered with questions pertinent to the assumptions, (3) after the session series semi-structured interviews were held with experts and moderators covering, among others, questions relating to the assumptions.

The questionnaire

The questionnaire contained ten statements that were rated on a five-point scale. Questions related to assumptions 1 and 2 asked participants to rate their understanding of the overall goal of the sessions, as well as whether the agenda and assignment for the sessions were clear. Other questions related to these assumptions as well as to assumptions on consensus building (7) asked participants to respond to the clarity and appreciation of work methods used, and to rate the extent to which they could contribute to the sessions and their appreciation of the collaboration in the team.

Other questions were related to the assumptions behind the model-centred approach (5 and 6). After the first session participants were asked to rate the clarity of the introduction to UML. In subsequent questionnaires participants rated their ability to read and explain UML models.

Results

In this section we report the results obtained from the experts. Wherever appropriate these results will be compared to those obtained from other participants in the sessions.

Assumptions behind the expert-driven nature

Table 1 summarizes the ratings of the understanding of the overall goal of the sessions. All medians are above the neutral point on the scale. Minimum and maximum ratings indicate that experts' opinions on this issue were diverging until session 4. During the final sessions they are more in agreement.

Table 1. Understanding of overall goal of the expert sessions

Session #	1	2	3	4	5	6	7
N	5	6	5	4	4	4	5
Mdn	4.0	4.0	4.0	4.0	3.5	4.0	4.0
Min	4	2	1	1	2	4	4
Max	4	5	5	4	4	5	5

As noted above, the overall agenda for the sessions was dropped. Perhaps this led some experts to be less secure on the overall goal. In their interviews experts indicate that maintaining the overall agenda could have improved the process.

After each session participants rated the clarity of the agenda and the assignment for the session and their understanding and appreciation of the methods that were used. The results are presented in Table 2. Overall, the session agenda's were rated as clear, but among the experts opinions vary. The ratings of the clarity of the assignments show a similar pattern as in Table 1 with differences among experts during the first three sessions.

Table 2. Session evaluation by experts

Session #	1	2	3	4	5	6	7
The agenda for the session was clear							
n	5	6	5	5	3	3	4
Mdn	4.0	3.0	4.0	4.0	4.0	4.0	4.5
Min	3	2	3	3	4	3	4
Max	5	5	4	5	5	4	5
The assignment for the session was clear							
n	5	6	4	5	3	4	4
Mdn	3.0	3.5	3.5	4.0	3.0	2.5	4.0
Min	2	2	2	3	3	2	3
Max	4	4	4	4	4	4	5

The moderators provided rates that in general were slightly lower than those given by the experts. They found the agenda of session 3 not clear (*Mdn*=1) and during that session their rating on the clarity of the overall goal was low (*Mdn*=2).

Assumptions behind the model-centred nature

Five experts provided a rating on the clearness of the introduction to UML (*Mdn* = 4.0, min=2, max=5). We also asked the experts to rate the extent to which they understood why UML was used in the project. Five experts rated their understanding (*Mdn*=4.0, min.= 2, max. = 4). Two experts provided the minimum ratings on both scales.

Table 3 presents the experts' rating of their ability to read the UML diagrams. There is a constant drop in the median rating until session 4, from whereon the experts start to rate their ability somewhat higher. Note that the range of ratings here is high until session 4 and the minimum ratings are very low.

Session #	1	2	3	4	5*	6
N	5	5	5	4	--	5
Mdn	4.0	3.0	2.0	3.5		4.0
Min	1	1	1	3		3
Max	4	4	4	4		4
* Due to an error in the forms used no data were collected in this session						

Table 3. Ratings of the experts of their ability to read the UML models

From session two onward the educational model for assessment was developed and after each sessions experts rated their understanding of the educational model, as well as their ability to explain the model to colleagues. Table 4 reports these ratings. Minimum ratings for understanding the model are at the neutral point. When the experts have to consider whether they could explain the model, the median rate remains positive, but the high range of the rates indicates important differences between experts.

Table 4. Ratings of understanding of the educational model developed

Session	1	2	3	4	5	6	7
	Understand educational model developed in current session						
n	n.a.	5	5	5	4	4	5
Mdn	n.a.	4.0	4.0	4.0	3.5	5.0	4.0
Min	n.a.	3	3	2	3	4	4
Max	n.a.	5	5	4	4	5	5
	Can explain model to colleagues						
n	4	6	5	5	3	4	5
Mdn	4.0	4.0	4.0	4.0	4.0	3.5	4.0
Min	3	1	1	2	2	3	2
Max	4	5	5	4	4	4	4

The ranges of the rates presented above indicate that on several measures a majority of experts gave favourable ratings, whereas a minority gave unfavourable ratings. Closer inspection of the data revealed a pattern where two experts gave low ratings on the clarity of the overall goal of the sessions (Table 1), capability of reading UML (Table 5) and the capability to explain the model to a colleague (Table 6). On other scales with minima below 3 they were found to have rated these scores. Inspection of the session notes indicated that the contributions of these two experts were diminishing over the course of the sessions. This was confirmed in their post-hoc interviews. They indicated that they needed more time between sessions to prepare themselves. Although more experts reported this, these two experts indicated that the highly abstract and technical nature of most of the discussions made them feel they had little to add.

Assumptions behind the consensus-based nature

In the session notes as well as in the interviews consensus building emerges as a very tedious process. Experts rated the clarity of and their appreciation for the work methods and the collaboration with others in the session. As a proxy to consensus building we asked them to rate to which extent they could contribute to the session's work. The results are presented in Table 5 and Table 6. The clarity of the work methods was rated consistently above neutral for all sessions and with little differences only between the experts. The appreciation of these work methods, although in general positive, shows differences between the experts.

Some contrasts between experts and moderators seem to occur as well. The moderators rated the clarity and their appreciation of the work methods of sessions 3 and 4 lower (*Mdn* ≤ 2) than the experts. The median rating of the appreciation of the contribution to the session is at moderate high level. The range of ratings varies over the sessions. Whereas experts sometimes express that they could not contribute much to a session, they all rate the collaboration in the team as positive.

Table 5. Clarity and appreciation of work methods

Session	1	2	3	4	5	6	7
			The work methods to be used were clear				
n	5	5	5	5	4	4	5
Mdn	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Min	2	3	3	3	4	3	3
Max	5	4	4	4	4	4	5
			Appreciation of work methods				
n	5	6	5	5	4	4	5
Mdn	4.0	5.0	4.0	4.0	4.0	4.0	3.0
Min	4	2	2	3	3	4	1
Max	5	5	4	4	4	4	4

Table 6. Appreciation of contribution and collaboration during the sessions

Session #	1	2	3	4	5	6	7
			Contribution to session				
n	5	6	5	5	4	4	5
Mdn	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Min	4	2	4	3	3	4	2
Max	5	5	4	5	5	5	4
			Collaboration with others				
n	5	6	5	5	4	4	5
Mdn	4.0	4.0	4.0	4.0	4.5	4.5	4.0
Min	4	4	4	4	4	4	4
Max	5	5	5	5	5	5	5

The moderators here, as well, tend to rate slightly lower than the experts. In sessions 4 and 7 their satisfaction with the collaboration with other group members drops below neutral (*Mdn*=2). The session notes as well as the interviews contain several statements in which experts complained about having insufficient time to prepare for the next meeting. Although the median ratings of the experts seem to indicate that they were satisfied with the techniques used and with the way of working that emerged, some experts felt more and more reserved to make a contribution. In their interview they indicated that this was due to the technical nature of the discussions. This is likely to be related to the centrality of the UML representation of the model.

Discussion

As a first step towards a methodology for building educational models, we took a closer look at the assumptions underlying our current practice that we typified as being expert-driven, model-centred and consensus-based. What we reported on is the perception of the participants of phenomena related to these assumptions, for example their reported capability in interpreting the educational model. These perceptions are often corroborated by the interviews or session notes.

The results presented here indicate that most assumptions were only partly met, certainly when we consider consensus building simultaneously with the two other characteristics. For example, experts had no problem to define and understand the overall and session goals, but this neither ensured that the goals were shared, nor that the goals or agenda were maintained. It took three sessions before all participants had a clear and corresponding view on the goals. Inspection of several other ratings demonstrate that behind the favourable median ratings are ranges that indicate that this was not a shared perception among experts.

It was assumed that experts could read basic UML models, that they could translate their knowledge to the UML models and test the presented models on their knowledge. However, on-the-fly modelling turned out to be a cumbersome process. The experts' rating of their ability in UML dropped steadily and even the increase in session 4 (see Table 3) may very well be the result of the absence of one of the experts who rated all the questions related to

UML low. In our interpretation on-the-fly modelling assumes more UML knowledge and experience than the experts could possibly bring to the sessions.

The assumption that UML would support consensus building did not hold. The session notes and interviews clearly show that consensus building was a very hard process. Yet, the ratings of the collaboration and contribution to the sessions do not indicate that there were conflicts within the team. In our interpretation consensus building was hampered by the interpretation of the UML model and differences of opinion on the importance of modelling particular aspects of the domain. This is supported by an observation made during the debriefing session. Here an outline of the model was presented without using UML notations. All experts agreed to this model, but they also indicated that opening up details would inevitably lead to new discussions.

In the sessions it became clear that the approach was based on a number of assumptions that proved wrong. The first sessions were spent on topics brought forward by the experts. Progress in modelling was extremely slow. It then became clear that not all work could be done in the sessions and that more preparation was needed. Then however experts reported that they did not have enough time to prepare between the sessions. During the fifth session the group decided that any further modelling would be done outside the group of experts, who would continue to function as a panel to discuss the resulting model. During the seventh session the moderators decided to take some time to recapitulate and model the final version by themselves (in fact, dropping their role) with the modeller and using the experts' input thus far. The eighth session was used as a debriefing session to present the final outcome and here the experts indicated they all were satisfied with that version of the model. The debriefing session also provided the opportunity to make suggestions for future modelling processes.

One might argue that the methods used both overrated and over-asked the experts. As far as modelling was concerned, the experts were clearly over-asked. On-the-fly modelling pre-supposed UML capabilities that our experts did not possess, or could have developed before or during the sessions. On the other hand, experts were overrated. They were the only source of knowledge used to structure the domain and to define the components of the model. Only in later stages the model was compared and contrasted to other models, as reported in Joosten-ten Brinke et al. (submitted). The expert-driven approach also led to deadlock whenever consensus could not be reached

Translating our experience into recommendations for future projects, we come to the following six points:
1. Establish a baseline reference for the project by collecting relevant sources and identifying the domain knowledge to be collected.
2. Avoid knowledge elicitation in large groups.
3. Separate modelling and knowledge elicitation.
4. Cater for expressing different views on the domain.
5. Use expert panels in combination with case descriptions to test and validate the model.
6. Define ownership and responsibilities. Who will own the model? Who will collect the domain knowledge? Who is responsible for modelling? How and by whom will the model be tested and evaluated? In order to avoid diffuse tasks and responsibilities these need to be defined for all persons involved in an educational modelling project.

These guidelines are no guarantee for success. Fortunately, failing to meet them has not caused a failure either. The model for assessment that was ultimately produced by the project was welcomed in a positive way by several independent reviewers and experts in assessment.

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Extending the SCORM Specification for references to the Open Content Object

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ABSTRACT

The Open Content Object (OCO), which was put forward in the author's previous paper, is an object that has the function of requesting services and providing services through the messages-passing mechanism, which relies on the Learning Management System (LMS) as the scheduling center of messages. The OCOs can offer a particular and flexible approach to designing the interoperable web-based content aggregation through its containers and organizing the learning sequence through the associational relationships between OCOs. This paper discusses how to extend the Sharable Content Object Reference Model (SCORM) Specification for applying the Open Content Object. The extensions to the SCORM Specification include extending SCORM's Content Aggregation Model and Run-Time Environment in light of the OCO's open characteristic. The paper also presents the XML binding and implementation of extending SCORM's Content Aggregation Model and some simple examples of using this extended reference model. The Open Content Object can be applied to the web-based learning contents through the extended SCORM specification presented by this paper, and it is hoped that the Open Content Object will offer some references for the next generation model of ADL/SCORM's content object.

Keywords

SCORM Specification, Content components, Content components reference model, Sharable Content Object, Open Content Object.

1. Introduction

Recently, in order to accelerate the development of the distance education based on the World Wide Web, many international organizations are researching and establishing the specifications for distance education. Notable among these initiatives are the AICC (1998), the IMS (1997), the IEEE/LTSC (1997), the W3C (1994), the CedMA (1991), the ADL (1999), the ARIADNE (1996), the CEN/ISSS (1997), the ISO/IEC JTC1 SC36 (1999) and the CETIS (2001). The interoperability and reusability are two common goals pursued by all the communities that are engaged in the technological specifications related to distance education. There are three levels of interoperability and reusability in all technological specifications related to distance education.

The first level is based on metadata, and the IEEE 1484.12.1 Learning Object Metadata (LOM) Standard (IEEE/LTSC, 2002) is the most typical specification. In this level, learning resources described by metadata can be systematically searched and retrieved for use and reuse. The information that describes a learning resource by metadata elements includes the name of learning resource, author, owner, terms of distribution, and format. The metadata specifications enable only the sharing and exchange of single learning resources across any technology-supported learning systems, but prevent aggregating several learning resources into an interoperable collection.

The second level is based on content aggregation, of which the most typical specification is IMS Content Packaging Specification (IMS, 2003b). Through the implementation of Content Packaging Specification, designers and implementers of instruction can aggregate learning resources to be an interoperable collection for the purpose of delivering a desired learning experience. In order to easily aggregate, share, and reuse learning resources, at present, IMS Content Packaging Specification requires that the structure of the independent learning resources be closed in a content package, so that learning resources can be used even though they break away from the context of learning content. However, because of the close structure of the sharable resources, the resources in a content package have only the relationships of functional complementarity with each other , namely they can be aggregated to compose higher-level units, but they do not provide service for each other during operation. Therefore, the object-oriented characters of learning systems are not integrated (Rumbaugh et al., 1991).

The third level is based on learning sequencing, of which the most typical specifications are IMS Simple Sequencing (SS), (IMS, 2003c), and ADL/SCORM Sequencing & Navigation (SN) (ADL, 2004d). At this level, designers and implementers of instruction can represent the intended behavior of an authored learning experience so that any Learning Management System (LMS) will sequence discrete learning activities in a consistent way. This level of interoperability and reusability is the most advanced and leads to new instructional technologies such as intelligent instruction and real-time guidance (Sleeman, 1982). This level is also the most complex and requires more flexible approaches to designing learning sequences in a content package. At present, for designing advanced learning sequences such as the branched learning sequence, both the IMS SS Specification and the SCORM SN lie on ADL/SCORM advancing Sharable Content Object (SCO)(ADL,2000), which is a new learning object that can be tracked by an LMS. The SCO can communicate with an LMS at run-time, so that different learning contents, approaches, and styles can be designed for different learners according to their abilities and performances. Because of the requirement that the structure of learning objects must be closed in a content package, SCOs can only communicate with LMS, but not with each other, so, at present, the interoperable learning sequence must be all designed in a content package that is outside of content components, and the design should conform to the rule of sequence specifications based on XML (IMS, 2002; IMS, 2003d; ADL, 2004e). The XML (W3C, 1998) is a markup language that implements data exchange. Its strength is data description (Birbeck, et al., 2001; Decker & Melnik, 2000); but using it to control the learning flow is inefficient and complex.

To reduce the above side effects, which are caused by the closed structure of content components, the author puts forward a new content-components model in a previous paper, which breaks through the closed structure of content components on the basis of the SCORM's SCO (Sharable Content Object) (Xinhua, 2005). Its basic idea is to extend the component-unit of the learning content to be an Open Content Object (OCO) that has the function of requesting services and providing services by the message-passing mechanism which relies on the Learning Management System (LMS) as the scheduling center of messages. The open characteristic of OCO is that the structure and function of an OCO can be extended by sending messages to LMS for requesting other OCOs to provide services. This open-components model allows content components to form the interoperable associational relationship by describing the message mapping about the requested OCO object's appointment in a content package, and makes the object-oriented characters of the learning systems more comprehensive and integrated. Therefore, this components model enables the learning sequence to be partly implemented within the OCO object by sending messages in Java scripts or Java applets, while the message mapping that appoints associational relationship between OCOs is described as an interoperable standardized manner in content packages outside of the OCO objects. So this approach to designing learning sequence is more flexible and effective than both the IMS SS and the SCORM SN specifications.

The Open Content Object model is only a conceptual one in the author's previous paper As for the applications of the Open Content Object, a correlative reference model, composed of a content aggregation model and a run-time environment, must be designed. This paper will present how to accomplish the extensions to SCORM Specification (ADL, 2004b) for the Open Content Object in light of the open characteristic of the Open Content Object.

2. Extending the SCORM Specification for the Open Content Object

Nowadays the definition and application of the specifications in distance education are implemented through Extensible Markup Language (XML) (W3C, 1998). Every definition of specification's format is described in a name space of XML schema. The XML has the inherent extensibility that is future-oriented compatibility (Martin et al, 2000; Walmsley, 2002). So, on the one hand, the specifications are allowed to refer to each other, e.g. the IMS Learning Resource Metadata Information Model (IMS, 2001a) refers to the LEEE/LTSC's Learning Object Metadata Standard, and the ADL/SCORM Specification refers to the IMS Content Packaging Specification (IMS, 2003b) and AICC Computer Managed Instruction Data Model (AICC, 2000a); on the other hand, every specification can be extended by software development groups according to their demands (IEEE/LTSC, 2002; IMS, 2003a), e.g. Wenchih et al(2004) propounded that "Enhancing SCORM metadata for assessment authoring in e-Learning", and Changtao & Wolfgang (2004) propounded that "Integrating XQuery-enabled SCORM XML Metadata Repositories into an RDF-based E-Learning P2P Network".

The open characteristic of the OCO is evolved from the characteristic that ADL/SCORM's SCO can communicate with a Learning Management System (LMS), so the Reference Model for the Open Content Object also consists of an Aggregation Model based on SCORM Content Aggregation Model and a Run-Time Environment based on SCORM Run-Time Environment, and it extends the relevant SCORM's sub-specifications in light of the OCO's open characteristic. The extensions to the SCORM Specification mainly include the following points:

1. In order to describe the requesting services from others and the providing services for others in an OCO , two sub-elements ,<requirement> and <service>, are added to the <general> element of SCORM Metadata Specification.
2. In order to unify the naming of message and method that are used within all the OCOs in a content package, two sub-elements ,<message> and <method>, are added to the <resource> element of SCORM Content Packaging Specification.
3. In order to describe the message mappings between the OCOs in a learning experience, a <messagemapping> sub-element is added to the <item> sub-element of the <organization> element of SCORM Content Packaging Specification.
4. The OCO Launch Scheme is extended to be one that allows LMS to launch more than one OCO for every learner at a time.
5. In order to enable an OCO to request LMS to launch the service object for it, a function Launch (message_responder) is added to the SCORM Application Program Interface (API).
6. In order to enable an OCO to send the messages of the service request to the LMS, three mandatory elements, <message_name>, <message_responder> and <message_responsemethod>, are added to the SCORM Data Model.

3. Extending the SCORM Aggregation Model for the Open Content Object

As the SCORM specification, the Aggregation Model for the Open Content Object also consists of a Metadata Model and a Content Packaging Model. It is aimed to provide a common method of packaging, issuing and exchanging for OCO-based learning contents. The Aggregation Model for the Open Content Object can be established on the Metadata and Content Packaging of the SCORM Content Aggregation Model (CAM) Version 1.3 (ADL, 2004a), and it extends properly the relevant SCORM specifications in light of the specific description information that is needed when OCOs are aggregated.

3.1 Extensions to the SCORM Metadata Information Model

"Information about information" is called metadata (IMS 2001a; W3C, 2001a). "Describing the components with metadata facilitates the search and discovery of the components across systems. An LMS could use the metadata to give the learner information about the content organization (i.e., course, lesson, module, etc) (ADL, 2004a). The SCORM Metadata Information Model refers to the IEEE 1484.12.1-2002 Learning Object Metadata standard (IEEE/LTSC, 2002) and the IEEE 1484.12.3 Draft Standard for Extensible Markup Language Binding for Learning Object Metadata Data Model (IEEE/LTSC, 2004). The SCORM Metadata Information Model is made up of elements of ten kinds, which are <lom>, <general>, <lifeCycle>, <metaMetadata>, <technical>, <educational>, <rights>, <relation>, <annotation> and <classification>. The element of each kind describes the characteristics of certain aspect of about content components, among them the <general> element describes the resource as a whole. An OCO may be a receiver of services as well as a provider of services, so in the OCO resource metadata, two kinds of information, the services requested to others and the services provided to others, should be described respectively. Therefore, two sub-elements should be added to the <general> element in the extended SCORM metadata Specification; their formats are as follows:

< requirement > element

- Description: This element describes the characteristics and functions of a service requested by an OCO, and the name of the corresponding message.
- Multiplicity: This element should occur 0 or more times within a <general> element.
- Sub-elements:
  - <message>: This sub-element describes the name of the message sending to LMS when this service is requested within an OCO ,and it must occur 1 and only 1 time in a < requirement > element.
  - <langstring>: This sub-element describes the characteristics and the functions of this requested service.

< service > element

- Description: This element describes the functions of a service provided by an OCO and the method name of performing these functions.
- Multiplicity: This element should occur 0 or more time within a <general> element.
- Sub- elements:
  - <method>: This sub-element describes the method name of performing this service provided by an OCO ,and it must occur 1 and only 1 time in a < service > element.
  - <langstring>: This sub-element describes the functions of this service.

The <langstring> sub-element can occur 0 or more times within the < requirement> and < service > element. However, each langstring is required to contain a different xml:lang attribute (ISO, 2002). Generally, a typical OCO resource describes the requesting list and service interface in its perfromace through several <requirement> elements and <service> elements in its metadata when it is issued, so that the OCO resources can be correctly reused in different learning systems.

3.2 Extensions to the SCORM Content Packaging Model

The purpose of the content package is to provide a standardized way to exchange learning content between different systems or tools. The content package also provides a place for describing the structure (or organization) and the intended behavior of a collection of learning content (IMS, 2003b; ADL, 2004a). SCORM Content Packaging Model is a set of specific use examples, or application profiles, of the IMS Content Packaging Specification (ADL, 2004a).

A content package manifest conforming to SCORM Specification consists of Metadata about the package, an optional Organization section that defines content structure and behavior, and a list of references to the resources in the package.

The SCORM Content Packaging Model supports only the aggregation relationship between content components. While in an OCO's content package, the OCOs can not only form the aggregation relationship with each other, but also set up the association between themselves by message mapping. In order to realize the establishment of the association between OCOs, it is necessary to make correspondent extension to the Organization elements and Resource elements in the SCORM's content package manifest.

3.2.1 Extensions to the <resource> element

In a content package, the different OCOs may be designed by different developers, so the message names for requesting service and method names for responding the requests, which are used within the OCOs, may not be unified between different OCOs. The different messages or methods within different OCOs may have the same name, so all messages and methods must be renamed and unified in a content package. Therefore, two sub-elements, <message> and <method>, should be added to the <resource> element (IETF, 1998). Their formats are as follows:

<message> element

- Description: This element uses an identifier in the content package to rename a message within an OCO.
- Multiplicity: This element may occur 0 or more times in a <resource> element.
- Attributes:
  - Identifier: A label for this message, which is globally unique within the content package.
  - Messagenameref: A reference to the name of this message within an OCO.

<method> element

- Description: This element renames a method within an OCO using an identifier in the content package.
- Multiplicity: This element may occur 0 or more times in a <resource> element.
- Attributes:

- Identifier: A label for this method, which is globally unique within the content package.
- Methodnameref: A reference to the name of this method within an OCO.

Compared with the SCORM's SCO, the OCO is a newly increased learning resource. In order to enable an LMS to correctly identify, launch and track an OCO, the type of the <resource> element referring to an OCO must be indicated to be "OCO". For this purpose, the SCORM's resource type attribute must be extended, and a new resource type of "OCO" is required to be added.

3.2.2 Extensions to the <item> sub-element of the <organization> element

In the IMS content package and the SCORM content package, an <organization> element is responsible to describe the content structure and sequence rules in a learning experience, so the association between the two OCOs should also be described in an <item> sub-element of the <organization> element. Therefore, a sub-element <messagemapping> should be added to the <item> element so as to describe the message mappings and to represent the association between the two OCOs in a learning experience. Its format is as follows:

<messagemapping> element

- Description: This element describes the message mappings between the OCO resource referred to in an <item> element and other OCOs.
- Multiplicity: This element may occur 0 or 1 time in an <item> element.
- Sub-element :<mapping>.

<mapping> Sub-element

- Description: This element describes a message mapping between the OCO resources.
- Multiplicity: This element may occur 1 or more times in a <messagemapping> element.
- Attributes:
    - Message: A reference to the identifier of a requesting message sent by the OCO resource referred to in this <item> element.
    - Responder: A reference to the identifier of the OCO resource that responds to the requesting message.
    - Responsemethod: A reference to the identifier of the method that really responds to this requesting message within the responding OCO.

3.3 The XML binding and implementation of the extended SCORM Aggregation Model

The Aggregation Model for the Open Content Object is an extension to SCORM's Metadata Specification and Content Packaging Specification. The method to implement these extensions (IMS, 2003a; IEEE/LTSC, 2004; W3C, 2001b; Walmsley, 2002) is as follows:

1. The extensions to the SCORM Metadata Specification and to the Content Packaging Specification are respectively defined in two different name spaces. Therefore, two XML Schema files should be built up to define the corresponding elements.
2. In an OCO's content package, when the extended element is used, a prefix representing its name space must be appended.

The implementation of the extensions to the SCORM Content Packaging Specification and its use will be introduced as an instance in the following text. The implementation of the extensions to the SCORM Metadata Specification is analogous with the instance.

3.3.1The implementation of the extensions to the SCORM Content Packaging Specification

The extended elements of SCORM Content Packaging Specification are defined in a XML schema file OCOCP.xsd (ADL, 2004e ;Walmsley, 2002; W3C, 2001b; Martin et al., 2000), which contains a hypothetical schema name space: "http://www.OCORM.org/xsd/ococp_v1p0" . The content of OCOCP.xsd schema file is listed and shown in the Appendix A.

3.3.2 How to use the extended elements in an OCO's content package

In an OCO's content package, all the elements that are used respectively adhere to three different name spaces (IMS, 2001b; IMS, 2003a; W3C, 2001b; Walmsley, 2002):
1. The name space of IMS Content Packaging Specification.
2. The name space of the elements extended by SCORM Specification to the IMS Content Packaging Specification.
3. The name space of the elements extended by OCO Aggregation Model to the IMS Content Packaging Specification.

In an OCO's content package, only the name space of IMS Content Packaging Specification is defined as the default name space. Therefore, when the elements extended by the OCO Aggregation Model are used, a prefix "ococp" representing the name space of the OCO Aggregation Model must be appended. An instance of the OCO Content Aggregation Model is given in Appendix B.

4. The Run-Time Environment for Open Content Object

The SCORM Run-Time Environment (RTE) provides an interoperable method for its Sharable Content Object(SCO) to run between multiple Learning Management Systems (LMSs), including a common way to start SCO learning resources, a common mechanism for SCO learning resources to communicate with an LMS and a predefined language or vocabulary forming the basis of the communication (ADL, 2004c). The Run-Time Environment of Open Content Object (OCO) is based on the SCORM Run-Time Environment; and it extends properly the SCORM RTE in light of the specific message passing mechanisms which is needed by the OCOs to implement their associational relationship. The structure of the OCO Run-Time Environment is shown in Figure 1.

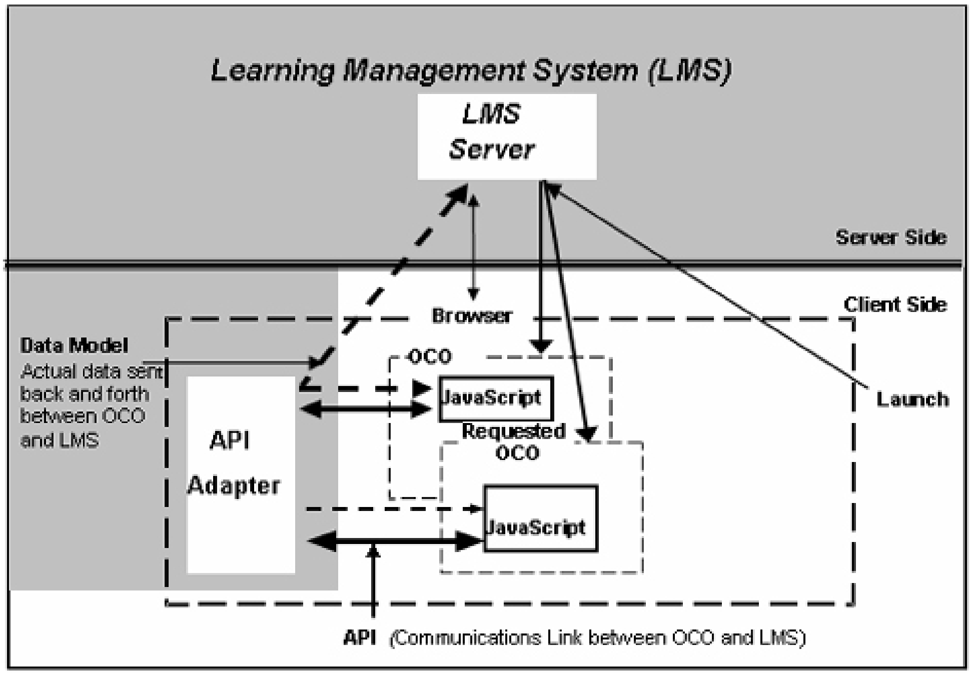

Figure 1. The OCO Run-Time Environment based on SCORM's

4.1 Extensions to the SCORM Launch Scheme

The SCORM Launch Scheme requires that an LMS only launch one SCO at a time and that only one SCO is active at a time. The SCORM Launch Scheme also requires that only LMSs may launch SCOs, SCOs may not launch other SCOs (ADL, 2004c).

In the extended SCORM Specification for OCO, an OCO can request other OCO objects to provide services at run-time, so the OCO Launch Scheme should be extended to be one that allows an LMS to launch more than one OCO for every learner at a time and maintains an independent communication data structure for every launched OCO in the LMS. But among the OCOs that were launched at a time, only one OCO is still in active-state, and others are in interrupted inactive-state, so that the LMS can manage and track those OCOs. Therefore, the multi-OCOs that have been launched in learning system will be executed in turn in an interruption-based serial way, but not in a parallel way.

The OCO run-time environment still keeps that only LMSs can launch OCOs, and OCOs can not launch other OCOs . When an OCO requests another OCO to provide services, it must send a message to the LMS through an API calls, then the LMS launches the requested OCO and interrupts the instructional activity of the current OCO. This Scheme of launching the requested OCO is very important to keep the interoperability and reusability of the associational relationship between OCOs.

4.2 Extension to the SCORM Application Program Interface

The SCORM is based directly on the run-time environment functionality defined in AICC's CMI001 Guidelines for Interoperability document (AICC, 2000b). The functions of the SCORM Application Program Interface (API) Adapter object are threefold (ADL, 2004c):

- Execution State: Two of the API functions, Initialize() and Terminate(), handle execution state.
- State Management: The API has three functions that are used to handle errors. They are: GetLastError(), GetErrorString(errornumber) and GetDiagnostic(parameter).
- Data Transfer: The remaining three API functions are used to transfer data to and from an LMS: GetValue(data model element), SetValue(data model element, value) and Commit().

The API Adapter object of OCO's RTE still keeps the above functions, but it is required to add a function Launch(message_ responder) that enables an OCO to request the LMS to launch a service object. The function's format is as follows:

Launch (Parameter)

- Description: This function allows an OCO to request the LMS to launch a service object.
- *Syntax:* Launch(parameter).
- Parameter: A reference to the identifier of the OCO that responds the current message. The referred identifier can be returned from the API calls of GetValue("cmi.message_responder") .
- Return Value: String representing a Boolean:
  - "true" result indicates that the Launch () was successful.
  - "false" result indicates that the Launch () was unsuccessful.

4.3 Extensions to the SCORM Data Model

SCORM Run-Time Environment Data Model derived directly from the AICC CMI Data Model described in the AICC CMI Guidelines for Interoperability. All data model elements described by SCORM are required to be implemented and their behaviors supported by an LMS. All data model elements are optional for use by SCOs. SCOs are required only to use the API functions Initialize("") and Terminate(""); they are not required to use SetValue() or GetValue(). SCOs may be very, very small and not designed to be tracked in detail. However, if they are to be tracked, they must conform to a common data model for reusability across multiple LMS environments (ADL, 2004c).

The OCO Run-Time Environment Data Model keeps the structure and data elements of the SCORM Data Model, and in order to enable an OCO to get the mapping information of the current service request message form the LMS, it is required to add three mandatory elements, message_name, message_responder and message_ responsemethod, into the SCORM Data Model. Their definitions, usages and data types are as follows:

cmi.message_name

- Definition: Normally, the official name used for the message within the OCO.
- Usage: Used to represent the message official name within the OCO.
- Data Type: CMIString255.
- Supported API calls: GetValue(), SetValue().
- LMS Behavior:
  - This data model element is mandatory and shall be implemented by the LMS as read/write.
  - When an OCO object set this data element through a SetValue() API calls, the OCO needs only to send the name of message to be used within the OCO. The LMS is responsible for translating this message name within the OCO into a message identifier uniformly nominated within the content package. The LMS achieves this translation by querying the message mapping described in the content package.

cmi.message_ responder

- Definition: Unique alpha-numeric code or identifier that refers to an OCO object of the LMS system.
- Usage: Used to represent the identifier of the OCO that responds to the current message.
- Data Type: CMIIdentifier.
- Supported API calls: GetValue().
- LMS Behavior:
  - This data model element is mandatory and shall be implemented by the LMS as read-only.
  - The LMS is responsible for initializing the cmi.message_ responder data model element based on the result that LMS queries the corresponding <messagemapping> element in the content package . The LMS queries this <messagemapping> element according to the current value of the cmi.message_name data model element.

cmi.message_ responsemethod

- Definition: Normally, the official name used for the method within the OCO.
- Usage: Used to represent the name of the method that really responds to the current message in the OCO.
- Data Type: CMIString255.
- Supported API calls: GetValue().
- LMS Behavior:
  - This data model element is mandatory and shall be implemented by the LMS as read-only.
  - The LMS is responsible for initializing the cmi.message_ responsemethod data model element based on the result that LMS queries the corresponding <messagemapping> element and <method> element in the content package according to the current value of the cmi.message_name data element.
  - GetValue():The LMS shall return a method name within the OCO, and this method is the responder of the current message.

4.4 The state transitions of the OCO requesting service and the OCO responding service

An OCO shall send a message to the LMS when requesting another OCO to provide services at run-time. After receiving the message, the LMS shall query the message mapping information in the content package to locate and launch the OCO that responds to the request, and meanwhile, the current OCO will be interrupt by the LMS, and after the responding OCO has ended，it will be resumed. Figure 2 and Figure 3 respectively shows the transitions of the state between the OCO requesting service and the OCO responding service.

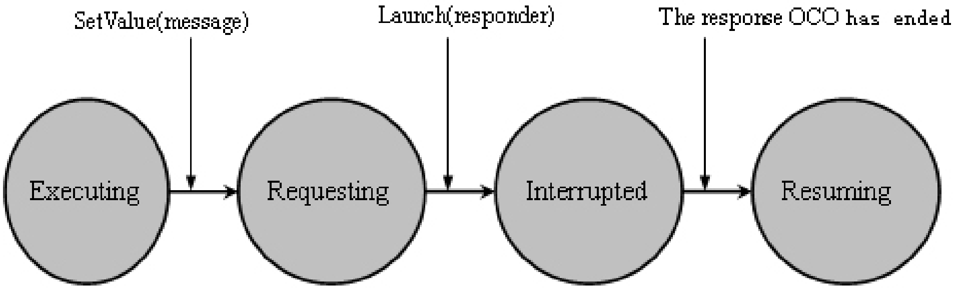

Figure 2. The state transitions of the OCO requesting service

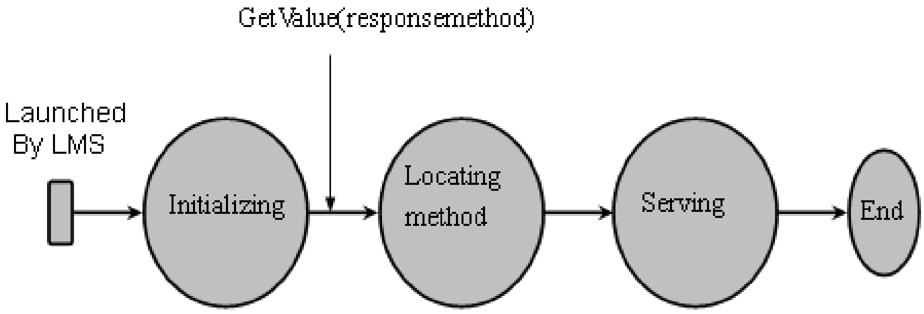

Figure 3. The state transitions of the OCO responding service

4.5 An instance of the implementation of designing the service request and service response within the OCO

In the process of designing an OCO, when an OCO object needs other's service in the handling procedure of an instructional events, at first it sends a message that requests the service to the LMS through a SetValue (message_name) API calls, then gets the responder of the message from the LMS through a GetValue(message_responder) API calls, and finally it requests the LMS to launch the responding object through a Launch(message_responder) API calls. These can be implemented by the following fragment of JavaScript program(Gibbons & Fairweather, 1998).

```
function OnInstructionalEvent(message)
{
  api.SetValue ("cmi.message_name","message");
    //This calls shall set the data model element of cmi.message_name into
       the supplied message name. The LMS shall translate this message name
       within the OCO into the message identifier uniformly nominated within
       the content package by queriying the <message> element in the
       <resource> element of the content package
  var responder=api.GetValue("cmi.message_responder");
  if (responder != NULL)
     api.Launch(responder);
  else
    //If there is no object to provide response within the content package,
      the responding code should be provided by this OCO
}
```

The OCO that responds to a service request, in its internal procedure for initialization, firstly gets the name of the method that responds to this request from the LMS by a GetValue(message_responsemethod) API calls, and then performs the service by calling the corresponding method. These can be implemented by the following fragment of JavaScript program (Lewis, 1987).

```
function initialization
{
  var responsemethod = api.GetValue("cmi.message_ responsemethod");
     //This calls shall return the name of the method that responds to the
       current service request from the LMS .
  if (responsemethod == NULL) defaultmethod();
      //If there is no service request, the OCO will provide the default
        learning content for the learner directly. The OCOs that don't
        provide any service for other will start operating from this entry
  else if (responsemethod == "methodname1") methodname1();
      //The OCO shall call the corresponding method to perform the requested
          service
  else if (responsemethod == "methodname2") methodname2();
    . . .
  else if (responsemethod == "methodnameN") methodnameN();
}
```

In fact, the OCOs that provide the services for other and the OCOs that don't provide any service for other have the same structure in the initializing procedure. According to different conditions of launch, an OCO may provide the default learning content for the learner directly, or it may call some method to respond to a service request of another OCO.

5. Conclusions

Through the extended SCORM specification presented by this paper, the OCO can be applied on the following two aspects:

1. Designers can use the containers of OCO to aggregate learning contents.
2. Designers can use the associational relationship between OCOs to organize learning sequences.

In the IMS and SCORM Content Packaging specifications, to absolutely ensure the reusability of content components, the content components can not refer to any external learning resources in direct or indirect way and all components in a content package are equal and independent, and there is no container that contains any other components. For these reasons, the object-oriented character of the learning system is not completed and integrated, so the aggregation of learning content can be only designed outside of the content components according to the content packaging specification (IMS, 2003a; ADL, 2004a), and the learning sequence also can be only designed outside of the content components according to the rules of sequence specifications (IMS, 2003c; ADL, 2004d). This causes the design of the content aggregations and learning sequences to be complicated and inefficient. After the Open Component Object (OCO) is designed for the web-based learning content model, the learning contents can be aggregated through the OCO's containers, and the learning sequences can be organized through the associational relationship between OCOs. This particular approach to designing the content aggregations and the learning sequences can't be found in the present specifications. Appendix C and Appendix D give two application instances to show the use of OCO in the design of the content aggregation and learning sequence. But because of the associational relationship between OCOs, the OCO content components model will weaken the independency of learning resources, and the OCO objects are required to map much information when being aggregated within a content package and to bind much information of metadata when being moved with a package from one LMS environment to another.

Using containers to aggregate the resource components also occurs in the MPEG-21 Digital Item Declaration (DID)(ISO/IEC, 2005), which is a digital resources packaging approach established by the ISO/IEC in the multimedia framework (MPEG-21)(ISO/IEC, 2004) .MPEG-21 DID offers a general Data Model that describes a set of abstract terms and concepts for defining Digital Items. Within this model, a Digital Item is the digital representation of a "work" (e.g., a digital music album or an e-book), and a Container is defined to be a grouping of

Containers and/or Items; designers can use the Containers and these groupings of Items and Containers to form logical packages (ISO/IEC, 2005). There is an essential difference between the containers in the MPEG-21 DID and the containers of OCO. The containers in the MPEG-21 DID are formed by statically describing their components of items before being delivered to the users, and they are aimed to decompose a resource component to be several smaller units of items and to reduce the redundancy of resource aggregation. Whereas the OCO containers are formed by dynamically sending messages to the LMS at run-time, and they are aimed to increase the flexibility of the content aggregation and to simplify its structure.

At present, many research groups and corporations have extended the SCORM Specification when appling it to software systems or software development tools. For example, Wenchih et al (2004) extended SCORM metadata according to an assessment analysis model for e-Learning operations, and incorporated the measured aspects of the following list into the SCORM metadata description at the question cognition level, the item difficulty index, the item discrimination index, the questionnaire style and the question style, and finally implemented an assessment authoring system based on extended assessment metadata to help teachers in authoring examination. Macromedia (2002) also designed a Wrapper Extension for Dreamweaver MX to support and extend the SCORM Run-Time Environment; the Wrapper Extension can automatically inserts all necessary JavaScript code and HTML tag attributes to automatically find the API object provided by the management system. It also calls the Initialize and Finish methods of the object per the ADL specification requirements. The Wrapper Extension extends the Data Model of SCORM Run-Time Environment by adding an optional element that represents the completion status of a lesson. As for, all extensions to SCORM specification are only based on the some or other aspect of the SCORM specification. , and as the author known ,there is no paper like this one extends the SCORM Content Object, SCORM Aggregation Model, the SCORM Launch Scheme and the SCORM Application Program Interface one by one.

In this paper, the messages passing mechanism, which implements the associational relationship between OCOs, is implemented by extending the Application Program Interface (API) and Data Model of the SCORM Run-Time Environment Specification. In fact, the IMS Shareable State Persistence Information Model (IMS, 2004a; IMS, 2004b; IMS, 2004c) can also implement the messages passing mechanism.

The Open Content Object can be applied to the web-based learning contents through the extended SCORM specification presented by this paper, and the Open Content Object may offer some references for the next generation model of ADL/SCORM's content object. In future, the author will focus on how to design a particular Flow Control Object based on the Open Content Object and how to establish a Learning Sequencing Model based on the Flow Control Object.

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APPENDIX A

OCOCP.xsd File Listing:

```
<xsd:schema targetNamespace="http://www.OCORM.org/xsd/ococp_v1p0"
    xmlns="http://www.OCORM.org/xsd/ococp_v1p0"
    xmlns:xsd=http://www.w3c.org/2001/XMLSchema>
  <xsd:attribute name="ocormType">
     <xsd:simpleType>
        <xsd:restriction base="xs:string">
              <xsd:enumeration value="oco" />
             <xsd:enumeration value="sco" />
             <xsd:enumeration value="asset" />
        </xsd:restriction>
      </xsd:simpleType>
  </xs:attribute>
  <xsd:simpleType name="namerefType">
     <xsd:restriction base="xsd:string">
        <xsd:maxLength value="2000"/>
     </xsd:restriction>
  </xsd:simpleType>
  <xsd:element name="message" type="messageType" />
  <xsd:element name="method" type=" methodType" />
  <xsd:element name="messagemapping" type=" messagemappingType" />
  <xsd:complexType name="messageType">
    <xsd:attribute name="identifier" type="xsd: ID" use="required" />
    <xsd:attribute name="messagenameref" type="namerefType" use="required" />
  </xsd:complexType>
  <xsd:complexType name="messageType">
    <xsd:attribute name="identifier" type="xsd: ID" use="required" />
    <xsd:attribute name=" methodnameref " type="namerefType" use="required" />
  </xsd:complexType>
  <xsd:complexType name="mapType">
    <xsd:attribute name="message" type="namerefType" use="required" />
    <xsd:attribute name="responder" type="namerefType" use="required" />
    <xsd:attribute name="responsemethod" type="namerefType" use="required" />
   </xsd:complexType>
  <xsd:complexType name="messagemappingType">
    <xsd: complexCntent>
       <xsd:sequence>
           <xsd:element name="map" type="mapType" />
       </xsd:sequence>
      </xsd: complexCntent>
  </xsd:complexType>
</xsd:schema>
```

APPENDIX B

An Instance of the OCO Content Packaging:

```
<manifest identifier="Manifest" version="1.1"
   xmlns="http://www.imsproject.org/xsd/imscp_rootv1p1p2"
   xmlns:ococp=http://www.OCORM.org/xsd/ococp_v1p0
   xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
   xsi:schemaLocation="http://www.imsproject.org/xsd/imscp_rootv1p1p2.xsd
                         http://www.OCORM.org/xsd/ococp_v1p0.xsd">
   <metadata/>
   <organizations default="TOC1">
     <organization identifier="TOC1" structure="hierarchical">
       <item identifier="ITEM1" identifierref="OCO1" isvisible="true">
         <ococp:messagemapping>
           <ococp:mapping message="message1" responder=" RES3" responsemethod="method1"/>
         <ococp:messagemapping/>
       </item>
       <item identifier="ITEM2" identifierref="OCO2" isvisible="true">
         <ococp:messagemapping>
           <ococp:mapping message="message2" responder=" RES3" responsemethod="method2"/>
         <ococp:messagemapping/>
       </item>
     </organization>
```

```
   </organizations>
   <resources>
      <resource identifier="OCO1" ococp:ocormtype="oco" type="webcontent" href="lesson1.htm">
         < ococp:message identifier="MESSAGE1" messagenameref=" requirement1"/>
      </resource>
      <resource identifier="OCO2" ococp:ocormtype="oco" type="webcontent" href="lesson1.htm">
         < ococp:message identifier="MESSAGE2" messagenameref=" requirement1"/>
      </resource>
      <resource identifier="OCO3" ococp:ocormtype="oco" type="webcontent" href="help.htm">
         < ococp:method identifier="method1" methodnameref="help1"/>
         < ococp:method identifier="method2" methodnameref="help2"/>
      </resource>
   </resources>
</manifest>
```

In this example, it is supposed that the OCO3 can offer corresponding helps to the OCO1 and the OCO2 by using different methods. The OCO3 neither directly participates in any aggregation of content structure, nor is present in any sequence rule of SCORM. However, in the instructional experience, the OCO3 can be triggered to run by the corresponding instructional events of the OCO1 and the OCO2.. Thereby, a flexible content aggregation structure distinguished from IMS and SCORM specifications is formed.

APPENDIX C

An Instance of Aggregating Learning Contents through the OCO Container

Suppose there are three knowledge points in the same section of a course and their learning content components respectively are OCO1, OCO2 and OCO3. Now the three learning content components are required to be aggregated to compose a bigger learning unit. In this instance, we can design a container OCO4 that contains these three components to implement the aggregation, which is shown in Figure 4.

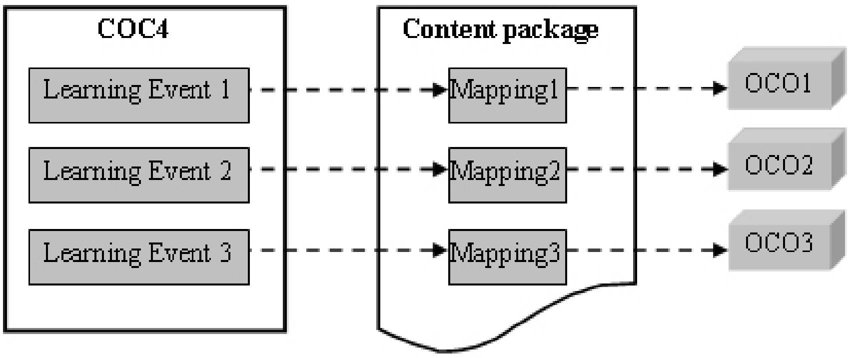

Figure 4. The structure of OCO Container

The detailed design steps are as follows:

(1) Three learning events, which can be triggered by some super-links, menu items or command buttons, are designed in the OCO4 container to control the navigational sequence of the three contained components.
(2) In the program handling learning events, the OCO4 container indirectly linked the three contained components by thrice calling the API function SetValue (message_name) to send corresponding messages to the LMS.
(3) In the manifest file of the content packages, only the OCO4 is an Item of in the aggregation structure, and the OCO1, the OCO2 and the OCO3 are only three responders of the OCO4's three messages, but not the items of the aggregation structure. Therefore, the structure of content aggregation will be simplified.

APPENDIX D

An Instance of Organizing Branched Instruction through the Associational Relationship between OCOs

The branched instruction shown in Figure 5 can be organized through the associational relationship shown between OCOs shown in Figure 6.

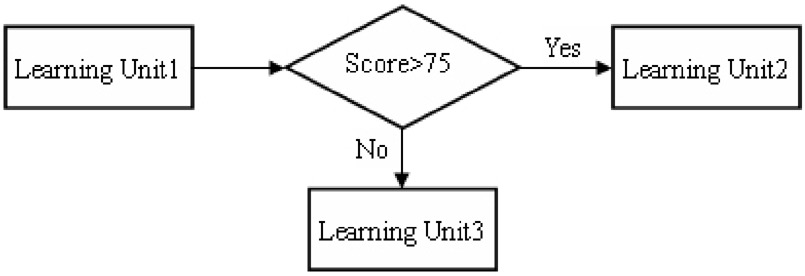

Figure 5. A flow of branched instruction

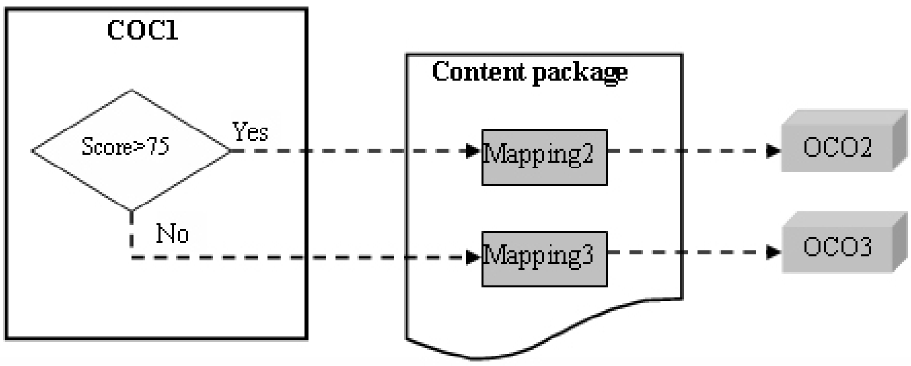

Figure 6. The OCOs' associational relationship applied to organize branched instruction

The detailed design steps are as follows:

(1) The preceding learning unit and two succeeding learning units are respectively designed to be three OCO objects, namely OCO1, OCO2 and OCO3.

(2) Within the learning object OCO1 , the following sentences to control branched flow will be added at the end of its program:

```
if (score>75)
   api.SetValue ("cmi.message_name","message1")
 //Send message1 to the LMS

else
   api.SetValue ("cmi.message_name","message2")
 //Send message2 to the LMS
```

(3) In the content package, the responder of message1 will be mapped into the OCO2, and the responder of message2 will be mapped into the OCO3 by an extended element <messagemapping> that is required for the content packaging:

```
<messagemapping>
   <mapping message="message1" responder=" OCO2" />
   <mapping message="message2" responder=" OCO3" />
</messagemapping>
```

Cronjé, J. C. (2007). Book review: Technology-Mediated Narrative Environments for Learning (Giuliana Dettori, Tania Giannetti, Ana Paiva and Ana Vaz). *Educational Technology & Society*, 10 (1), 265-267.

Technology-Mediated Narrative Environments for Learning

(Book Review)

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Textbook Details:

Technology-Mediated Narrative Environments for Learning
Giuliana Dettori, Tania Giannetti, Ana Paiva and Ana Vaz (Eds.)
Rotterdam: Sense Publishers, 2006
ISBN 90-77874-15-1
163p

How it all began

Sitting at my desk as visiting professor at the University of Bergen, Norway I received an email from Kinshuk asking if I would review a book for *Educational Technology and Society.* Of course I agreed, and within a week the book was delivered by courier. It was called *Technology-Mediated Narrative Environments for Learning*. From the introduction by the four editors, Giuliana Dettori, Tania Giannetti, Ana Paiva and Ana Vaz, I learnt that technology-mediated narrative environments were digital spaces in which learners could relate their own stories. The book was the product of a workshop arranged by the Special Interest Group *Narrative and Learning Environments* (SIG NLE) of the *Kaleidoscope* Network of Excellence. The merits of narrative in teaching and learning are obvious. Teachers have always been tellers of stories. However, following the work of Bruner (1990) we have been getting more and more aware of the fact that learners also have stories to tell. So this book, the introduction said, was about digital technologies that allow learners to tell their stories, much in the same way as "show-and-tell" sessions, puppet shows, etc have always been used for this purpose. So the book became my companion and reading materials as I spent six weeks attending three conferences in Europe.

The book at first glance

As can be expected of the product of a workshop, the book is an exploration of a concept rather than an explanation. The topics therefore are divergent, rather than convergent, and spiral out from the central theme of technology-mediated environments. Some chapters describe commercially available tools, others describe tools under construction. Some are case studies involving the use of such tools, and even others describe the use of existing narrative tools, such as video cameras and video editing suites, as elements of narrative environments. The book has thirteen chapters including the introduction.

The chapters, from two to twelve

Chapter 2 by Ruth Aylett, "And they both lived happily ever after" is an excellent theoretical foundation for stories and learning, identifying three uses of narrative, that of telling, authoring and role playing. The chapter also looks at the role of narrative and interactivity, and considers the issue of what makes a story believable. Chapter three, "Narrative-oriented software for the learning of a foreign language" by Jeffrey Earp and Tania Giannetti describes a number of programmes, such as *Story Maker 2*, *Kar2ouche composer.* They argue that these tools can only be used effectively if teachers ensure that their learners keep on track, based on the types of learners involved and the learning goals.

Bregje de Vries changes the focus in Chapter 4 to “Reflective narration with e-mail” when she describes a design experiment in which they considered how children wrote personal and reflective stories about their experiences. They worked from three perspectives, act, statement and story, and suggested that the theoretical underpinnings for this type of research needs to be strengthened, and that Design-Based Research formed a useful methodology.

In sharp contrast Chapter 5 contains Patricia Valinho and Nuno Correia’s description of “oTTomer” – an blend of physical space and interactive tools that allow children to immerse in role-play with a number of real and virtual characters. The next chapter is a single-subject case study called “Speak for yourself” that tells the story of a twelve-year old grade 7 special needs student who used multimedia authoring software to tell stories that, owing to learning difficulties, he would not have been able to tell through conventional text. Author Fern Faux calls for a less prescriptive curriculum and relaxed assessment methods that will allow us to credit students for their achievements in environments other than the ones traditionally used in schools.

In Chapter 7 Ana Vaz and Ana Paiva ask “Can character perspective induce reflection?” They describe a *FearNot!* application about bullying at school. They argue that for a learner to develop empathy with a character, the learner needs to identify with a particular character, rather than to be an outside observer. The aim of the project was to reduce bullying behaviour by encouraging bullies to develop empathy with their victims. Further plans will involve not only allowing learners to take various roles, but also to assess their changes in attitude, and later even to assess the coping strategies of children who are bullied.

Chapter 8, by Chronis Kynigos, Nicholas Kazazis and Katerina Makri, “On narrative perception and creativity” considers what happens when children aged from 10 to 13 engage in recording and producing their own video material. They identify two ways in which their subjects used the technology, the first group, called the “tellers” simply told the story with minimum use of video devices. The second group, called the “directors” exploited the various possibilities offered by the video editing programme to give expression to their own creativity.

Kevin Walker describes a really interesting project that blends real and digital environments in Chapter 9: “Story structures”. The premise is that people walking through a museum often only remember what they had seen years later, when prompted by another stimulus. Debriefing people directly after a museum visit is of little help, as they are usually physically and mentally tired. He then suggests the use of digital devices such as the *iPod* to record people’s experiences during the visit, thus creating a “learning trail”.

In Chapter 10, “Narrative for Motivation and Meaning Making”, Olga Timcenko describes an innovative use of narrative to augment or replace the traditional manual in teaching programming and application use in a Lego™ environment for children. Her argument is that people hardly ever read manuals, yet they like stories. Therefore an approach whereby a developer tells the story of how a certain solution was developed will motivate others to use the same procedures. Likewise, asking children to tell the stories of how they came to develop certain solutions creates readable project documentation, and gives us an understanding of what meaning was created and how.

Jarmo Laaksolathi, presents us in Chapter 11 with two “Methods for Evaluating a Dramatic Game”. The first is a Sensual Evaluation Instrument that captures players’ immediate non-verbal response to a game. The second is an existing method, Repertory Grid Technique that is used after the game to determine players’ subjective experience.

In Chapter 12 Giuliana Dettori and Tania Giannetti analyze the extent to which a multimedia authoring tool is able to support “Narrative Creation and Self-Regulated Learning”. They evaluate *Story Maker 2* and that self-regulation not so much about being free to regulate one’s own learning, but more about being able to do so. Self-regulated learning is a skill that has to be developed.

Chapter 13 – the summary

In the last chapter Carola Conle pulls the whole lot together with an analysis of the narrative and educational qualities of some of the programs discussed in the previous chapters. The really nice thing about her chapter called “Considerations on Technology-Mediated Narrative Learning Environments” is that, of all the authors in the whole book, she is the only one who actually uses *narrative* as a vehicle for her chapter – putting her money where her mouth is. She tells the story of how she made sense of the workshop that led to this book. She then, effectively presents a review of the book by presenting five “selections”. The first four selections consider aspects concerning students creating multimedia narratives. These selections concentrate on creativity and skill development. Selection five is about the way in which students experience professionally created multimedia narratives. Finally she relates “How an experience becomes a story and how stories become experience” (p. 154). Finally she presents some themes, questions and personal episodes.

What I thought

So that then is my blend of story and summary. I read the book on plains, trains and automobiles (with other people driving). Sometimes I had to leave it for a week or two because of other pressing matters. But eventually I had to sit down and work through it in one single session asking, “Who should buy this book, and why?”

The book is for researchers, teachers and developers with a genuine interest in enhancing the creative quality of education by incorporating the oldest form of teaching – narrative. The great strength of the book is that it provides the theoretical underpinnings required to analyse narrative learning environments and shows where theory is lacking. Then it presents a selection of excellent empirical studies that cover a wide range of applications. In this way the book forms an excellent resource for a student about to embark on masters’ or doctoral studies, who needs a good overview of the chosen field.

It is a pity then that a book that is all about the use of narrative, uses hardly any narrative in its style of reporting. All these authors do all this excellent work eliciting creativity in their learners – and then thy put it across in such a dry, academic style!
Nevertheless I found it a really useful resource. It opened my eyes to a whole lot of research questions. It is the sort of thing that a professor of computers and education should keep on the shelf.

Lan, C. H. (2007). Book review: Tools for Teaching Computer Networking and Hardware Concepts (Nurul Sarkar). *Educational Technology & Society*, 10 (1), 268-270.

Tools for Teaching Computer Networking and Hardware Concepts

(Book Review)

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Textbook Details:

Tools for Teaching Computer Networking and Hardware Concepts
Nurul Sarkar (Ed.)
2006, Information Science Publishing (an imprint of Idea Group Inc.)
ISBN 1-59140-736-2
http://www.idea-group-ref.com/books/details.asp?id=5546
386 pages

Introduction

This book introduces the innovative tools for teaching and learning computer networking and hardware. These tools assist teachers to overcome the cost problem and space constraints in teaching networking and hardware concepts and enhance students' participation in flexible learning activities. The book is organized in 18 chapters divided into 5 sections. It starts in Section I with an introduction and a presentation of the basic concepts necessary for a good understanding of computer networking and hardware. Section II provides an in-depth treatment of the software and hardware tools and lab activities designed to enhance teaching and learning various aspects of computer networking. Afterward Section III illustrates wireless networking concepts and information security risk analysis. Section IV describes the computer hardware concepts and tools, including processor simulator and lab activities. Finally, Section V discusses detailed coverage of learning tools and techniques related to data communication protocols.

Teaching and Learning Computer Networking

This section includes six chapters covering wired and wireless LAN design, communication networks and protocols. Chapter II introduces a Web-based tool called WebLan-Designer for class demonstration as well as modeling LAN design. The tool provides students an interactive and flexible learning experience in designing wired and wireless LAN and improves students' participation in learning activities. Chapter III describes another interactive learning tool called iNetwork that allows students to experiment with difference network configurations or build custom networks without the need for expensive equipments. The authors illustrate laboratory exercises with detailed process to demonstrate the usefulness of the tool in reinforcing and extending students' understanding of network topics.

Following computer networking concepts, chapter IV presents the use of a network simulator called Packet Tracer in practical exercises to encourage independent and analytical processes and facilitate deeper learning. The simulation tool provides visualization, animation and meaningful intrinsic feedback features which engage students during the practical concentration and interest. Chapter V describes the architecture of a protocol animation tool called JASPER that provides a graphical and dynamic learning environment in communication protocols. This tool animates well-known protocols and allows students to add new protocols. Students can gain real insight into protocol design, analysis and operation using the JASPER protocol animator.

It is often difficult to motivate students to learn computer networking due to its dry and boring theories. Therefore, chapter VI presents a framework based on a set of learning activities for enhancing teaching and learning various aspects of packet-forwarding theories and concepts. Through the framework and laboratory activities, teachers are able to liven-up lecture environment and students can gain insights into the concepts of packet-forwarding theories. Chapter VII emphasizes that students can view the abstract protocols as real artifacts that can captured and examined by using open source software called Ethereal. The proposed approach involves five activities, such as instruction, directed task, independent activity, novel situation and reinforcement. According to students' feedback, the tool gives students the ability to develop a better understanding of network protocols and problem-solving skills.

Wireless Networking and Information Security

This section focuses on wireless communication and networking technologies and consists of three chapters. In chapter VIII, the authors introduce a set of new projects in order to support teaching wireless networking and provide students hands-on practical work. A series of interesting wireless projects engage students to actively learn wireless communication and network fundamentals and reinforce their comprehension. Chapter IX provides a tutorial on the architecture of Wi-Fi networks, the evolution of IEEE 802.11 standards and radio propagation measurements using available wireless equipments (limited hardware and software resources). Through a series of experiments and measurements of the Wi-Fi projects, students indicated that they had learned a great deal about Wi-Fi fundamentals. Chapter X highlights a teaching hospital model developed for information assurance training in the context of information security risk analysis. The authors consider the difficulty in crystallizing theoretical knowledge into fled knowledge. Therefore, they propose the teaching hospital approach which involves incorporating real cases to supplement existing curriculum, keeps teaching material relevant over time through infusion of current research problems and creates a rich learning environment to support students to gain a deeper knowledge.

Teaching and Learning Computer Hardware

This section offers six chapters covering computer software and hardware tools. Chapter XI discusses the issues surrounding the communication between a processor, bus and external I/O devices. The author describes the organization of external I/O devices in detail. The practical operation explains how operating systems use I/O to access a computer's resources is presented along with some tools. Chapter XII presents the effectiveness of new PIC-based projects that facilitate an interactive, hands-on introduction to traditional computer hardware concepts. Students learn a great deal about hardware fundamentals by participating in the PIC projects and demonstration activities.

To provide suitable teaching suggestions to instructors in teaching computer hardware fundamentals, chapter XIII describes a novel assistant tool based on problem-based learning (PBL) theory. Through students' discussion about the brainstorm maps, the tool can construct the concept maps to assist teachers in knowing the concepts students lacked and the appropriate teaching sequence. Chapter XIV presents a useful processor simulator designed as an aim to teaching and learning the architecture of modern high-performance processors. The simulator written in Java is highly modular, and thus enables students to model individual processor modules on demand.

Chapter XV discusses the development and usefulness of a remotely accessible embedded systems laboratory that uses a small number of 32-bit development systems and can be accessed from any location with Internet. The proposed system provides students to learn in a convenient and secure way and makes distance education more practical. Additionally, chapter XVI shows a user-friendly tool named LOGIC-Minimister in enhancing teaching and learning minimization of Boolean expressions. The tool facilitates an interactive introduction on Boolean algebra, minimization of Boolean expressions, and logic gates and provides an opportunity for hands-on experience.

Data Communication Protocols and Learning Tools

This section consists of two chapters and provides learning tools designed to assist teachers and learners in teaching and learning the concepts of data communication protocols. Chapter XVII describes a practical introduction about the components of a serial protocol and explains how to use a protocol analyzer to examine any packet or frame. The proposed tool called Packeryzer not only promotes learners for the basic understanding of serial communication, but also enables network administrators to verify or evaluate the performance of a network. Chapter XVIII presents

VMware as a learning tool that emulates a hardware environment to transcend the traditional constraints of hardware solutions. The authors outline the feature sets of benefit for employing the tool and demonstrate the effectiveness through practical projects.

Summary

Although computer communication networking and hardware concepts are very important topics in computer education around the globe, many students appear to think the subject rather technical and tedious. Thus, it is necessary to liven up learning environment and guide students in exactly grasping these fundamental theoretical concepts. This book aims to establish a bridge between theory and practice in the fields of computer networking and hardware by adopting various learning tools. Not only does it cover a broad range of knowledge about wired and wireless networking, hardware, and protocols, but it emphasizes interactive hands-on exercises in order to motivate students to learning theoretical knowledge.

This book is a well organized and contains 5 sections and 18 chapters with detailed context. Each chapter includes learning objectives, figures and illustrations, key terms, real-world examples as well as review questions, all of which provide readers a useful conceptual resource. In summary, this book is really able to engage readers' full attention for the following reasons.

- It has a realistic objective that makes teaching and learning of computer networking and hardware a more active process by using these proposed methods and interactive tools.
- It was written as a unified whole in which each chapter relates its content to the introduction of concepts and is, in turn, related to the laboratory activities.
- Topics are reinforced by presenting the actual practices and the application of tools.
- It offers various learning tools that enable students to develop a better understanding of theoretical concepts and translate the abstract knowledge from the literature into a real-work situation.
- It includes many practical examples that support teachers to acquire more knowledge in how to apply software and Internet technology in inspiring students to learn computer networking and hardware fundamentals.

I deeply appreciate the precious experience of these authors in the areas of teaching and learning computer networking and hardware. Especially, I am interested in chapter IX titled "Teaching and Learning Wi-Fi Networking Fundamentals Using Limited Resources". The authors present complete teaching process including introducing basic concepts, designing an experiment, illustrating the software, evaluating the experiment result and student feedback. Through the integration between theory and practice, I believe surface learning is reduced and deep learning is increased. In addition, these proposed methods in this book have a positive effect on the teaching environment and are received favorably by students. Students become increasingly motivated to learn more about computer networking and hardware concepts and also realize how to apply their acquired knowledge to solve real-world problems.

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