Collaboration and Learning in Virtual Environments

Edited by Jeanette Bopry and Anneli Eteläpelto

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PART 4. INFORMATION AND COMMUNICATION TECHOLOGY IN SCHOOLING ENVIRONMENTS

INTRODUCTION

Anneli Eteläpelto and Jeanette Bopry

This publication on collaboration and learning in virtual environments is based on themes and issues that emerged during an international congress organized at the University of Jyväskylä, Finland. Although some time has elapsed since the discussion, the main themes that arose have not lost their relevance. On the contrary, the issues of collaboration and learning, especially in virtual environments, have even become more urgent. Researchers and practitioners alike are struggling with the problems of how to utilize virtual environments in such a way as to promote effective collaboration. They want to know exactly how information and communication technology can support high-level cognitive processes in classroom contexts. Teachers, for their part, wonder how their role as instructors will be changed as virtual learning environments become the norm. And parents wonder whether they should worry about their children's fascination with computer games. Clearly, everyone needs to know more about the psychological mechanisms influencing the phenomenon of learning in virtual environments. Although this book does not try to prescribe solutions to practical problems, it does aim to raise and delimit some central problems recently faced by those working and learning in virtual environments.125

Although information and communication technology has been widely introduced to most domains of human life, researchers have not yet come to an agreement of how virtual environments should be defined. From the 1980's, social scientists began to use the concept of 'virtual community' to describe people linked by e-mail and other similar systems on the Internet. Howard Rheingold (1993) defined a virtual community as follows: Virtual communities are social aggregations that emerge from the Internet when enough people carry on ... public discussions long enough, with sufficient human feelings, to form webs of personal relationships in cyberspace.

For Rheingold, virtual communities emerged in response to a widespread 'hunger of community', a hunger which is increased as more traditional types of communities disintegrate (Mercer, 2000). However, many communication researchers like Neil Postman and Neil Mercer have suggested that there are good reasons for being cautious about applying the term ‘virtual communities’. Compared with ‘community of discourse’ and ‘community of practice’, the term virtual community has been mostly used very loosely, and it has been suggested that, unless it is more precisely defined, it will be of little value. For this reason, instead of the concept of community, we use in this publication the concept of environment to refer to the virtual sites and places used as other environments of learning and working.

The virtual environments, which have emerged with the growth of the information society, do not exist in isolation from the wider social context. The information society, which is based on global information environments, has been characterized as a society in which knowledge is situated in dynamic web-like networks rather than in static, often hierarchical structures (Castels & Himanen, 2001). Information societies have also been characterized as learning societies which implies that continuous learning is a necessity for communities as well as for individuals. Moreover, learning is not something that takes place only in the context of schools and other institutions. Rather, it is a central constituent of human life – indeed, a way of life. Such a conception of learning corresponds to a definition of learning as something essential to human survival. This definition is all the more apt when our environment is undergoing continuous and rapid change.

If we accept that information is situated in networks, the role of collaborative knowledge production becomes essential. Collaboration thus constitutes an important building block of learning societies. Although educational and psychological research has traditionally focused more on the isolated learner, in today’s society it would be difficult to find domains of advanced expertise in which individuals would manage well on their own, without social interaction and collaboration. This is due both to the complex nature of advanced knowledge and to the need to combine different areas of knowledge and expertise while developing new products.

The following pages provide a short description of the main themes of the book. These include i) theoretical issues, ii) the social and emotional dimensions of virtual environments, iii) examples of problem-based learning in virtual environments, and iv) information and communication technology in schooling environments.

Part I. Theoretical Issues

This book begins by focusing on theoretical issues that are often neglected in discussions of virtual environments and their construction. The first two chapters both deal with epistemological issues of systems design, as well as with the nature of the constructive processes through which mental representations are created and used in human symbolic activities. They also deal with questions of how subjects construct understandings, including aspects of other people's practices and the construction of communication. By focusing on these questions (which concern human knowledge and communication, their nature and origin) the ultimate goals of virtual environments are demonstrated. In fact, the hype in western societies concerning revolutionary technological advances has tended to obscure the real meaning of these advances. The goal of constructing virtual environments is not the environments as such, but rather their ability to promote human understanding and communication, and it is according to this criterion that virtual environments should be evaluated.

In Chapter 1 *Jeanette Bopry* seeks an answer to the question of how to conduct design in a constructive manner, i.e. a manner which places the agency of the learner at its core. In analysing the philosophical background, Bopry shows that the design of information technology-based environments has been dominated by a technical rationalism which allots to the human actor a very passive role. In accordance with this conception of design, representational realism has dominated as a theory of the human mind and its functioning. However, since this approach does not perceive the learner as an autonomous agent, it does not serve as a sufficient model for designing constructivist learning environments. In asking how one would design virtual environments that would eschew mere technical rationalism, Bopry suggests as an alternative the theory of autonomous systems, as being more compatible with the constructivist conception of human learning.

It is not only the rationalist theory of mind, but also actual models of communication that have implications for the design of virtual environments. Bopry suggests that the information-processing model of cognition, which is based on representational determinism, should be rejected, since it perceives the receiver of the information as a container rather than as an active agent who makes subjective interpretations and constructs individual meanings. As an alternative model of communication Bopry describes a recursive model, giving as an example the creation of a virtual environment called CoVis (Collaborative Visualization Project). At the end of the chapter, Bopry addresses learner-determined design, in which the stakeholders are seen as actively participating in the design process. Her final area of concern is that of creativity and its necessary conditions.

The second chapter by *Edith Ackerman* takes up the challenge of redefining the term 'representation'. Ackerman suggests that the verb 'represent' should not merely refer to the description of what exists; it should also include more creative aspects of what does not exist but is imagined. Examples are taken from design activity and children's symbolic play; generalizations are extended to all kinds of symbolic activities. In such activities, people both construct and create symbolic worlds for themselves, and they project themselves as inhabitants of these worlds. In this kind of dialectic process, which is essential for human learning and personal growth, fusion and separation coexist.

Ackerman, who has worked in Jean Piaget's laboratory and has been involved in the development of the first world-famous computer-based learning environment, Turtle-Logo geometrics, makes an interesting synthesis of what developmental, cognitive, personality and social psychology have achieved in their understanding of human imagination. She describes how children and adults have the ability to construct symbolic worlds and project themselves into these imaginary worlds. Virtual environments constructed to support human creative abilities are contexts that foster self-directed, exploratory learning, and at the same time engage learners in playful self-projections. The digital children of today find themselves in such environments in fascinating computer games – games which inevitably engage the players' creative imagination and allow the projection of selves into symbolic worlds. The creatures of computer games can be understood as extensions of the subjects' own selves. These extensions can be used by children to control the creatures of the games, allowing the players to identify with the happenings of the games, such as mental teleportation. A microworld developed at Technical Education Research Center, Cambridge, MA, utilises the subjects' sense of bodily identification in conjunction with a motion-based model for the learning of mathematical concepts. Although Ackerman emphasises the importance of abstract thinking, she adds that abstract thinking itself would fade away over time if it were not constantly re-grounded at a very concrete and embodied level.

Ackerman also analyses the virtues of social virtual environments, such as MUDs. A MUD is a role-play game in which players, in anonymous interaction, can choose a role as close to or as far from their everyday selves as they wish. In MUDs, players construct their own manuscripts and use drama to mediate their experiences. Ackerman finds many advantages and possibilities offered by the virtual environments used in MUDs, as compared to adult psychodramas or face-to-face role-playing. There are implications for ways in which the education of digital children could be supported by text/voice-based environments involving distant-chat, story-telling and role-play.

In her discussion on novel perspectives based on different modalities of literacy, Ackerman offers fascinating insights. Using Ong's analysis of differences between oral and literal communication, Ackerman suggests that writing is a powerful tool for distancing, but that it separates author from audience, audience from the site of the plot, and word from voice. Print can be silent and cold, but it can be kept in storage. Speech, by contrast, is an integral part of human performance, which by its nature links what is said to who says it, and how it is voiced. Speech is more interactive in the sense that speakers can respond to their audience; moreover, speech allows the actor to be embedded in the pragmatics of the conversation.

Part 2. Social and Emotional Dimensions of Virtual Environments

The second part of the book addresses social and emotional issues of virtual learning environments. So far, research on learning has mainly focused on cognitive and knowledge-building aspects. By contrast, emotional and social issues are much neglected although their influence has been clearly recognised. The role of emotional issues in learning is self-evident for teachers and students in their everyday practice.

In virtual environments, emotional and social issues are, of course, also present, but their roles and manifestations are probably unlike those in traditional learning environments. Up to the present, we do not have enough understanding of the special meanings of the emotional and social aspects of virtual environments. As a consequence of this, we cannot fully consider or utilise these emotional and social aspects in designing powerful learning environments.

In Chapter 3, *Arvaja, Häkkinen, Eteläpelto and Rasku-Puttonen* ask how different kinds of contextual factors, especially those connected with subjects' social roles and their symmetry in a small group, interact with subjects' collaborative knowledge-building. The authors report research in which two different kinds of virtual environments were compared. Shared knowledge-building was analysed in terms of Mercer's categorisation of the quality of speech. The results demonstrated that high-level knowledge-building was characterised by a situation in which the participants had equal roles, and in which the learning task was formulated in such a way as to promote critical argumentation. By contrast, in leader-centred situations where there was great asymmetry in the participants' roles, both genuine collaboration and critical argumentation were totally absent.

From an analysis of the prevalence of different modes of speech in a small-group learning situation it appeared that critical joint knowledge-building was quite rare. It was much more common for uncritical knowledge sharing to occur, manifested as cumulative talk. The authors suggest that this was mainly due to the nature of the assignments that were given. The task encouraged the students to collect single facts rather than to engage in critical argumentation. The nature of the speech also seemed to be very sensitive to the nature of the social roles, especially their symmetry or asymmetry. The results seem to call for a critical discussion on the conditions and constraints of group work. Group work does not necessarily guarantee high-level learning. Various social and contextual factors must be optimal if positive outcomes are to emerge.

Chapter 4 addresses the emotional aspects of computer-mediated communication (CMC). *Sakhel*'s article contributes an interesting analysis of anonymity; this is an essential dimension, distinguishing the virtual environment from face-to-face-interaction. Anonymity is generally seen as a condition where participants can express anti-normative behaviour. It has also been thought that anonymity increases task-oriented behaviour, as opposed to promoting an emotional orientation. However, there are also models suggesting that anonymity may actually accentuate social influence.

Sakhel sought to answer to the question of how anonymity affects group discussion within a virtual environment. His results demonstrated that anonymity within a group may tend to promote normative behaviour. The study also suggests that, as compared to face-to-face groups, more social influence is present in anonymous groups, at least in terms of local group norms. The author concludes that computer-mediated communication may not tend to be task-oriented, as suggested by prior research. Rather, it seems that computer-mediated communication tends to contain socio-emotional interaction styles, and that social influence is mediated through such interaction styles.

Clearly, Sakhel's results do not give support to the common assumption that the fewer social cues which are present in virtual environments would imply a diminution in social influence. On the contrary, having fewer social cues may actually lead to increased attachment to the social aspects of the situation. Thus, we cannot suggest that computer-mediated communication would be less personally engaging than traditional modes of communication and interaction. However, more research is needed to confirm these hypotheses, which are clearly of great relevance to our understanding of virtual modes of communication.

Part 3. Problem-Based Learning in Virtual Environments

In problem-based and project-enhanced learning, meaningful and authentic problems are used as the starting point for learning; these usually involve relatively long-lasting co-operative or collaborative projects which are completed by a small group of students. In schooling environments, problem- and project-based learning seeks to simulate authentic working-life environments and give students an opportunity to participate in real-life activities.

Problem-based learning has been regarded as a powerful learning environment, especially for acquiring important working-life competencies. Various reasons have been given in the literature for using a problem-based learning model. Foremost among these are the theoretical underpinnings provided by socio-cultural and situated approaches to learning. These approaches emphasise the importance of participation in authentic communities of practice. In working-life oriented learning this implies (irrespective of subjects' existing participation in work organisations) taking authentic working-life problems as the starting point for curriculum design.

In research on collaborative learning, it has been suggested that an interactive process of collaboration triggers learning outcomes at a higher level than those achieved by individual learning. Nevertheless, empirical research on small-group and project-enhanced learning has shown that there are many problems in the promotion of high-level learning processes in collaborative projects. It has been found, for example, that individual learners may not share the responsibility for joint goals. In research on school-age children it has also been found that learners are seldom able to ask the kind of questions that would trigger elaborated explanations. This means that learners have difficulties in sharing and utilising the background knowledge they possess as separate individuals, as they would need to do in order to take advantage of group-based learning. It seems also that individuals must have good metacognitive awareness of their own background knowledge before they can frame elaborated questions on things they need to know more about. Overall, research indicates that certain individual- and group-level conditions are necessary for successful project-based learning. These include, for example, interactional skills that would enable learners to ask, describe and make visible their own thinking and knowledge, and self-evaluation skills to evaluate their own background knowledge.

A second argument for using problem-based learning arises from research on professional expertise, and from the perceived need for higher education to produce qualifications relevant to future working life. Critics have focused on discrepancies between higher education on the one hand and students' real needs in future working life and future expert environments on the other. With this in mind, problem-based learning environments are intended to simulate learning environments similar to those of working life.

The third reason for using problem-based environments in schooling contexts is that of motivation. One would expect students to be more motivated by meaningful tasks, and by problems which take as their starting point the environment in which the students are going to work. It has been thought that if students are highly motivated they will then engage in the active processes needed for constructive learning. Moreover, these are processes which are fostered by project- and problem-based learning. In this type of learning, students need to redefine problems, to search for new information, and to evaluate and compare it with their prior knowledge; they need to make abstractions and generalisations and arrive at a shared knowledge product.

In the construction of virtual learning environments for professional learning, a problem-based paradigm has been used in various domains. The third part of this book examines virtual environments that have been constructed in the domains of social economics and nursing.

In Chapter 5 *Ulrich Björk* describes a learning environment that utilises conferencing, which is seen as a powerful part of Computer Mediated Communication (CMC). In conferencing, computers are used as a tool for communication. Björk focuses on students' use of problem-based learning in an on-line environment, his purpose being to gain a better understanding of innovative collaborative learning. He demonstrates how a model of problem-based learning can be successfully integrated into on-line courses on social economy.

In the following chapter (6), *Hans Rystedt* and *Berner Lindström* address the issue of developing nursing expertise in simulation-based learning environments. First of all they describe the work of nurse anaesthetists, which is done in a high-technology environment, in close collaboration with other professionals. The development of nursing expertise in this field is of vital importance, and educators naturally wish to discover appropriate computerised pedagogical tools.

Rystedt and Lindström investigate how the use of one tool, the simulation-based learning environment, can contribute to learning in the domain of anaesthesia care. Using the sociocultural theory as a framework, the authors suggest that the use of computer-based learning environments can influence subjects' assessment procedures and decision-making skills in significant ways. The authors present results from a study in which trainee nurse anaesthetists were taught using computer-simulations. They describe the planning, implementation and debriefing phases of one training session, analysing the subjects' framing of problems, and the implications for their learning. The authors conclude that computer simulation-based learning environments provide a powerful means for collaborative learning.

In the following chapter (7) *Charles Docherty* and *Helena Topp* present an enquiry-based virtual learning environment. They describe the design, production and evaluation of a computer-facilitated problem-based simulated clinical environment which aims to foster the practical skills of nursing students. The project integrates problem-based learning and learning technology in the context of a simulated clinical laboratory. In addition, the authors seek to develop an appropriate evaluation strategy for the piloting of the project and to produce a framework for other modules. The facilities are located in Glasgow Caledonian University, where a purpose-built 'hospital' provides simulated environments in which nursing skills can be acquired.

The system should allow students to enter into an unfolding problem-based learning scenario. In addition to the simulation activities, the system incorporates tutorial discussions and lecture sessions. There will also be communication with facilitators and dialogue with peers across the network. Working in small groups, students will utilise a realistic intensive-care environment in which a computer system is central to organising guidance, support and direction. It is expected that through collaborative role-play activities utilising authentic resources, students will approach the level of performance demonstrated by examples within the multimedia resources of the system. Students will be expected to undertake self- and peer-assessment; they will be encouraged to e-mail their facilitators in preparation for group discussion and reflection sessions, and finally to provide evidence of their performance on video, for group discussion.

The evaluation framework which has been developed as an essential quality control mechanism is suited to curricula utilising both virtual and problem-based learning environments. The theory underpinning this evaluation framework is discussed. The formative evaluation of the system is multi-focal and comprehensive, while the summative evaluation takes a multidimensional and flexible approach. It is argued that both types of evaluation are essential in determining the quality of learning within a virtual environment.

Part 4. Information and Communication Technology in Schooling Environments

Analyses of small-group discussions have indicated that high-level learning is manifested in the quality of talk. Accountable talk, which contributes to the construction of learning communities, has been described as argumentative and exploratory. Talk of this kind involves actively listening to what others have to say, the elaboration of other participants' messages, and building on ideas presented by others. It is further characterised by the identification and challenging of misconceptions, the construction of various explanations, and the testing of understanding through demands for evidence to back up suggestions and arguments.

Such talk is implies a very demanding mode of discussion, and it will seldom emerge spontaneously. Indeed, many empirical studies on real-life learning situations have demonstrated a scarcity of argumentative or exploratory talk. A more common mode of speech is cumulative talk where participants merely list and uncritically construct on top of each other's ideas.

The fourth part of the book addresses the use of information and communication technology in schooling environments. Chapter 8 focuses on the teacher's role in project-based learning utilising technology-based environments. *Helena Rasku-Puttonen, Anneli Eteläpelto, Maarit Arvaja* and *Päivi Häkkinen* start off by remarking that much of the research on collaborative learning has focused on student interaction, but that we must also recognise the powerful influence of the teacher on student collaboration. We need to know more about the best ways to support productive collaboration at different stages of project work, the types of specific help that scaffolding should include and the specific criteria to be applied for gradually reducing support. The present study aims to investigate how the teacher endeavours to promote collaborative learning in project work, and how this in turn affects the processes and outcomes of the shared work of students.

The study described in this chapter was carried out as part of an authentic science learning investigation. Lower secondary school students worked in a network-based Globe environment in which they carried out laboratory experiments and analysed and reported research findings. The results indicate the critical role of the teacher in the promotion of productive collaborative learning. The teacher has to offer proper instructional support, reframing argumentation and fostering shared problem-solving, and thus modelling an expert-like manner of critical reasoning. The findings revealed that many problems of collaborative learning are related to how well the teacher is able to offer proper support at appropriate moments and to their awareness of students' thinking processes. The teacher's role is further discussed in relation to two factors: time and the organisational structure of the (traditional) schooling context. The paper also includes a discussion of students' ability to communicate their need for help.

In the following chapter (9) *Saija Mäki-Komsi* and *Eero Ropo* focus on modern media and instructional technology in vocational adult education. The purpose of the study, which is part of the OpinNet project, was to investigate teachers' experiences of educational and cultural changes in adult education institutions. The initial assumption was that the institutional shift from traditional teacher-dominated, face-to-face teaching to networked teamwork (emphasising students' independence) is not only a methodological or technological change, but also a cultural one. It affects the entire institution. And along with a multi-level transformation of the practices and procedures in the institution it requires also a complete rethinking of teaching, learning and studying. Given the major transformations needed, it is obvious that changes in the teaching culture will be slow and gradual. The research task was to study teachers' experiences of modern instructional technology in adult vocational teaching, and also to examine the experiences of the students.

The results showed that all the institutions were undergoing or starting a process of changing their teaching practices – and also their basic assumptions about vocational education. The subjects described the difficulties in transforming instruction from traditional classroom teaching into multimedia instruction, with particular reference to the crucial roles of distance-learning and teaching. There are likely to be changes in the 'balance of power', due to students' independence in goal setting and in making curriculum decisions. This kind of change did indeed seem to be a major challenge to the teachers' previous conceptions of learning and teaching. The teaching culture had to struggle with the idea of changing from knowledge transmission practices to becoming 'midwives' to learning.

The last chapter (10) of the book presents a virtual learning environment developed at Helsinki University of Technology to teach information technology. *Ari Korhonen* and *Lauri Malmi* present and evaluate a learning environment for a course in data structures and algorithms. The system combines standard telematic tools such as e-mail, newsgroups and WWW pages with a dedicated tool devised for this particular course. This combination has proved to be highly successful in a mass course taken by hundreds of students.

The need to deal with the large numbers of students attending basic courses has led the teachers to try out a number of telematic tools. In addition to these, several other tools have been developed to aid studies, especially in the programming courses. One of these is the WWW-TRAKLA system, which is used for teaching data structures and algorithms. This is a dedicated tool for the delivery and automatic checking of algorithmic assignments. It is an integral part of the course, enabling teachers to provide more assignments than would be possible using merely human resources. Personally tailored non-trivial assignments can be used, with immediate feedback available to the students, who can correct their own answers. Very good learning results have been achieved using this system.

The TRAKLA system has been used in Helsinki University of Technology since 1991. During the first years all communication with it and with the students was carried out by e-mail. In 1997 a Web interface was added. Within the current project there has been a great deal of discussion by teachers on the role of various telematic tools in education. Experience has shows that each tool can have its own role, but that the roles often partially overlap each other. Interestingly, the teachers feel that standard tools such as e-mail, newsgroups and WWW pages are quite adequate for building a good learning environment. This view to some extent goes against the current trend, which has moved towards the development of integrated learning environments, for example, the WebCT tool.

The authors argue that integrated environments have problems which traditional tools do not share. First of all, the students have to learn a new system instead of using the kinds of general-purpose tools which they use in their everyday communication. Secondly, the teacher is obliged to carry out a certain amount of maintenance work when a more obvious way would be to use system maintenance resources. Thirdly, it is not so obvious how new facilities can be added to these tools, in cases where the existing properties fail to meet the needs of a particular course.

The authors have experience of their system's adaptability, since they use the TRAKLA system for the registration of the students. In any case, the point is that TRAKLA uses standard tools for communication, and the authors can see no advantages in using it in parallel with some integrated tool. They conclude that what is needed in courses is a simple way of configuring an environment for each course separately, using standard tools and a loose interface which allows dedicated tools to be added to the environment as required.

All in all, the chapters in this book are relevant not so much for what has already been achieved – though that is considerable – but for the challenges they open up. The future will certainly see a further developing and refining of virtual environments, and better ways of addressing their quality and effectiveness as tools for learning. There will be more research on the authenticity of the environments; at the same time, the constraints that might stand in the way of their application to real-life situations will be better understood. Through research in these areas we shall develop powerful virtual environments for the future.

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1. Issues of Educational Design in Virtual Environments

Jeanette Bopry

In technological environments, it is easy to fall into a pattern of technical rationality in dealing with design issues. This has a number of negative implications if one takes a learner-centered perspective. In particular, it negates learner agency, an essential component of constructivist and social constructivist positions. Most design models currently available to educational technologists are products of the technical rational tradition, yet today, many educational technologists consider themselves constructivists. In order to resolve this problem the designer must be able to avoid technical rationality when working in technological environments. This, unfortunately, is more easily said than done.

What is Technical Rationality?

Donald Schön describes technical rationality in the following way: Technical rationality holds that practitioners are instrumental problem solvers who select technical means best suited to particular purposes. Rigorous professional practitioners solve well-formed instrumental problems by applying theory and technique derived from systematic, preferably scientific knowledge. (Schön, 1987, pp. 3-4).

What does this mean in the context of educational technology? Educational technologists define technology as a process. The definition recommended by Heinich, Russell, and Molenda (1986, 1996) is:

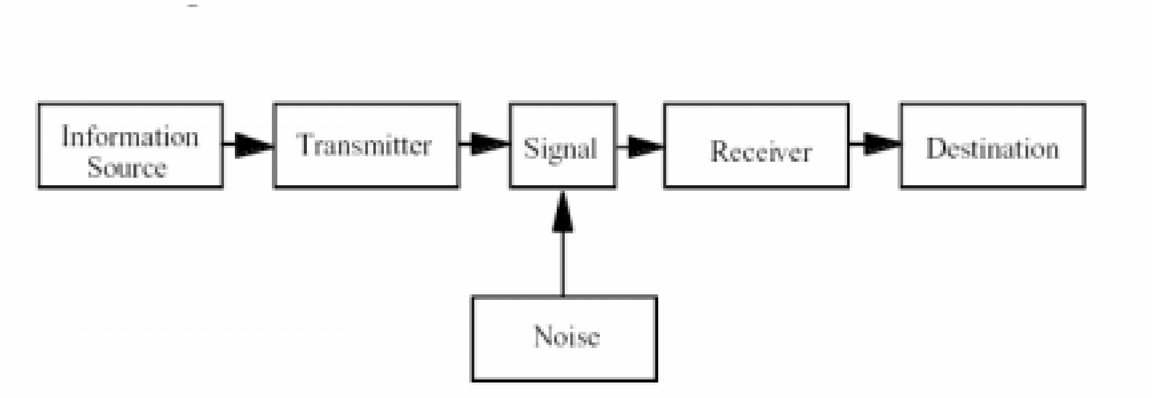
> Technology means the systematic application of scientific or other organized knowledge to practical tasks. Its most important consequence, at least for purposes of economics, is in forcing the division and subdivision of any such task into its component parts. Thus, and only thus, can organized knowledge be brought to bear on performance. (Galbraith, 1967, p. 12)

The definition of technology accepted by many educational technologists is the epitome of technical rationality. Technical rationality itself is part of what is called the rationalistic tradition, the position that undergirds science and technology in western culture. In this tradition conscious rational thought is considered the basis for sound action. Emphasis is placed on the form that rules take and the processes through which they are logically applied. Rationalistic thinking is often equated with intelligence itself (Winograd & Flores, 1986).

According to Winograd and Flores (1986) rationalistic theories of mind adopt some form of representational hypothesis. All thought is the manipulation of representational structures in the mind. There is a dualism between the objective world of physical reality and the subjective mental world: actions happen in the ‘real world’; there are objective facts about this ‘real world’ that do not depend upon the interpretation of, or even the presence of, a human being; facts are registered (often inaccurately) in our thoughts and feelings through our perceptual systems; and, our intentions can cause ‘real world’ (physical) action.

If one accepts representational realism (a common philosophical position), one accepts that the environment instructs the nervous system in such a way that it creates representations, possibly maps, of the environment. In other words, the environment has a deterministic effect upon the nervous system. People can also have a deterministic effect upon one another through language and other forms of communication. This is borne out in models of communication. Model based on a representational perspective are likely to be deterministic, and, indeed such communication models are common (Shannon & Weaver, 1949; Berlo, 1960; Schramm, 1954). According to these models words are the vehicles that carry meaning from one person to another. Information, knowledge, and meaning can all be moved from sender to receiver. This metaphor is generally called the conduit metaphor; the role of the receiver is that of container. The ideas, knowledge, and information attributed to one person can be placed in the brain of another through the conduit. The primary responsibility for communication resides with the sender. The role of the receiver is relatively passive. Receivers do make mistakes and it is incumbent upon the sender to anticipate and avoid such errors or correct them when they happen. Within a representational perspective some sort of mediator, some mechanism, some controller or central processor must exist in order to compare the representations that the receiver has created of an environment with the actual environment.

Figure 1: The Shannon Weaver Communication Model



(Shannon & Weaver, 1949)

So, Why is this a Problem?

What does it mean to apply technical rationality to the problems of cognitive systems? Following the premises of technical rationality cognitive processes can be determined given the appropriate presentation. Educational technologists will be intently interested in getting their message just right. Information provided in a presentation will 'instruct' the nervous system of the receiver of the message in a deterministic or probabilistic manner. Information and often knowledge are mind independent entities that can be transmitted from the presenter to the receiver. Because information and knowledge carry meaning, meaning may also be transmitted. The receiver's cognitive processes, then, are open to inputs. The presenter or designer is responsible for what the receiver learns. Understanding results from receiving information, knowledge and meaning. Since receivers are not considered autonomous agents, deterministic models of communication preclude consideration of understanding as a basis for communication; further, they preclude consideration of the cognitive reflexivity that would make an understanding-centered model of communication possible. Learner agency is negated. This negation has led to a situation where students consider learning something that someone else does to you, rather than something you do for yourself (Johnson & Taylor, 1991).

Is there an alternative viable framework to technical rationality?

If one has sympathy with a constructivist position, all of these beliefs and their implications are called into question. Educational technology as a form of technical rationality does not adequately provide for the agency, reflexivity, and understanding that characterize empowered learners. If we wish to engage in practice that accounts for these characteristics we need to consider alternative frameworks. Enactive constructivism provides such an alternative. It is able to avoid some of the unfortunate implications associated with the application of technical rationality to cognitive systems because the intertwined concepts of agency, understanding and reflexivity are central to this perspective. This framework provides some direction for those educational technologists who wish to engage in humanistic approaches to education.

Enactive constructivism is an interactionist position that transcends the physical/mental dualism: existence and interpretation are the same thing (Heidegger, 1962). Reality is a social construction where at least two people must recognize an experience for it to be considered "real." This means that many distinct realities may exist; we live not in a universe, but as Maturana (1988) would have it, in multiverses. The acceptance of such a position demands tolerance of the reality constructions of others and allows one to expect the tolerance of others toward one’s own construction. In this framework our primary way of relating to the world is not through representations that correspond to it, but through interacting with it. Effective action allows us to join on-going worlds of meaning or shape new worlds of meaning.

Enactive constructivism is a cybernetic framework associated with two related theoretical developments: autopoiesis theory and autonomous systems theory. The enactive constructivist position is derived from these theoretical developments, so educators have reason to be interested in both. Although a special case of autonomous systems theory, autopoiesis theory both antedates autonomous systems theory and provides its conceptual foundation. The only distinction between autopoietic and other autonomous systems is that autopoietic systems produce themselves (i.e., they are alive). All autonomous systems depend explicitly on circularity, and all autonomous systems distinguish themselves from an environment. So, why make the distinction at all? The primary advantage of focusing on autonomous systems rather than autopoietic systems is that autonomous systems theory can more appropriately be applied to social systems.

Some of the problems related to technical rationality are the result of the misapplication of the organismic metaphor to nonliving systems (i.e., treating nonliving systems, especially social systems, as if they were alive). The application of autopoiesis to social theory would suffer from the same difficulties as the organismic metaphor. To quote Maturana:

> To believe that the spontaneous course of transformation of a society as a biological unity may lead to a non-oppressive system that does not negate the individual is, biologically, a delusion. (1974, p. 466)

Autonomous systems theory represents an attempt by one of the developers of autopoiesis theory to avoid this problem (See Varela, 1979). Autonomous systems theory provides a legitimate source for important concepts while avoiding the complications of the organismic metaphor. The primary metaphor of autonomous systems theory, as is the case with recent cybernetic theory, is the conversation, not the organism.

There are four important concepts associated with these theories that the education should be aware of: organizational closure, structural determination, structural coupling, and effective action. Organization is essentially the criterial characteristics (static and dynamic) of an entity, those that specify its identity, or its inclusion within a class or category of entities. Organization must be conserved or the entity’s identity will change. For a system to be autonomous it must exhibit organizational closure: a circular concatenation of processes that constitutes an interdependent network (Varela, 1979). Inputs from and outputs to the environment have no impact on processes that constitute the organization of an autonomous entity; those processes that comprise its organization are closed to such interactions. Educators should be aware that the nervous system is one such system; it evinces its organizational closure in terms of neuronal activity. Neuronal activity leads only to more neuronal activity.

> As a closed neuronal network the nervous system has no input or output, and there is no intrinsic feature in its organization that would allow it to discriminate through the dynamics of its changes of state between possible internal or external causes for these changes of state. (Varela, 1979, p. 242)

This means that the nervous system does not discriminate between what we call "hallucination" and what we call "perception." Such a system does not input or output information (Maturana, 1974). The organizational closure of the nervous system has consequences for our understanding of representation and communication (Varela, 1979). Information is not found in the environment, it is constructed by the individual in interaction with the world. The individual’s constructions are constrained, not determined, by the world and the social context in which we live. We cannot escape responsibility for the world we construct.

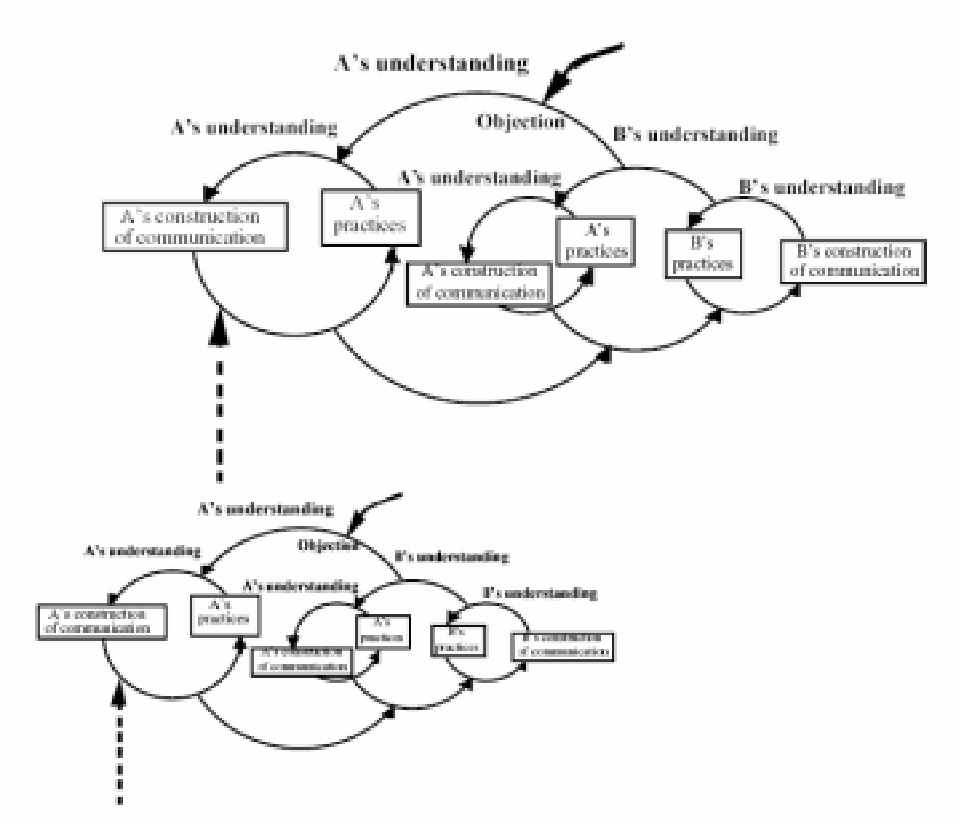
A system will resist any attempt to alter its organization; such attempts pose a threat to its identity. However, systems do change. Change that occurs in a system without threatening its identity is structural change. Structure refers to the physical properties and the actual relationships of the components of a given system. Organization itself is an abstract concept; structure is a physical instantiation of an organization. A structure may undergo a variety of changes that do not threaten its organization. Any interaction with the environment may trigger such a change. However, such interaction does not determine what that change will be. That is determined by the structure of the system undergoing change. For example, for some of us bee stings pose a real danger, for others they are a minor annoyance. In an educational context then, learning is controlled by learners; educators can only trigger changes in learners that may result in desired learning outcomes. For the living cognitive system, structural determination means that any information available to that system is produced by criteria internal to the workings of the system itself (Maturana & Varela, 1987).

If we accept organizational closure and structural determination we must reject the information-processing model of cognition. Information cannot be carried from the environment to an observer or from one observer to another. This is an important distinction to make because those educational technologists who consider themselves constructivists generally hold that while knowledge is constructed, information may be transmitted. From the enactive position, they are taking the illogical position that the cognitive system's organizational processes may be simultaneously open (to information) and closed (to knowledge).

If information cannot be transmitted between individuals, how is communication possible? The mechanism that accounts for communication is structural coupling. When an entity is in continuous interaction with an environment or with some other entity, so that there is mutual triggering of structural change over time that becomes stable in nature, the two entities are said to be structurally coupled. This is essentially a form of mutual adaptation and is the basis for communication in living systems. Within this framework, communication can be understood as a form of mutual adaptation that occurs over a span of time. Autopoiesis theory has inspired an alternative to deterministic models of communication in Krippendorff's Recursive Model of Communication.

According to Krippendorff (1994) self-reference is a defining feature of communication, thus his recursive model of communication is centered on understanding. We understand ourselves, understand each other, and understand each other's understanding of ourselves. As long as two people can carry on a conversation without "objections" being raised that signal disagreement or misunderstanding, the pair will assume that they share an understanding. If an objection is raised, the matter will be negotiated until the belief in a shared understanding is again reached. There is no outside intervention in understanding, no transmission of meaning. In contrast to the transmission model of communication which assumes that communication should be easy if senders know what they are doing, the recursive model of communication assumes that communication is very hard work, and depends upon a commitment to mutual respect and understanding by all parties involved in the process. This model of communication has implications for the conduct of design, pointing toward more collaboration with all stakeholders in the design process.

Figure 2: Krippendorff's Recursive Model of Communication



Note: Based on model in Krippendorff (1994)

Effective action is closely tied to structural coupling; it is essentially adaptation that works. In nature, survival and reproduction are the ultimate measures of effective action. The mechanism of effective action is structural coupling. Successful communication is one example of effective action, successful design is another. It should be apparent that in all human activities effective action is the goal.

Designing Virtual Environments that Avoid Technical Rationality

Design that avoids technical rationality will have identifiable characteristics. These would include: learner-determined design (which is consistent with our understanding of structural determination); the creation of community in disembedded environments (in order to provide opportunities for structural coupling); and the design of opportunities for creativity (which would focus design on the effective action of the learner).

The creation of community. Virtual environments, like the internet, provide opportunities for the creation of communities that otherwise could not exist. Learners are able to make connections with other learners at large geographical distance and with experts whose responsibilities preclude real time interactions with the group. An example of such a community is the CoVis or Collaborative Visualization Project, developed in the 1990's, which scaffolds the study of atmospheric and environmental sciences by students around the world. The CoVis learning environment is made up of students, teachers, scientists, science educators and educational technologists (Edelson, Pea & Gomez, 1996). While it emulates a scientific community of practice, the primary goal of CoVis is not basic research, but science education. In the CoVis environment students have access to the same data and research tools as scientific practitioners; specifically, students have access to visualization tools similar to those used by scientists to represent and to understand data. Brown Collins and Duguid (1989) remind us that the proper use of the tools of a given community requires the adoption of "the belief system of the culture in which they are used" (p. 33). In order to become proficient in the use of the tools of the scientific community, students must become peripheral members of that community by adopting its system of values. The CoVis environment allows student to experience firsthand the activities engaged in by scientists rather than their descriptions and explanations of their work.

Learner-determined design. In most design fields usability has become a real issue (Adler & Winograd, 1992). There seems little sense in engaging in design that will not be used. Involving end-users (i.e., learners) in the process of design is one way to ensure that product of design will be used. Dorsey, Goodrum & Schwen, for example, recommend rapid collaborative prototyping, where endusers become co-designers of instructional products. Banathy (1994a, 1994b, 1996) recommends that stakeholders become the primary designers of systems to solve their own problems. This ensures not only the use of the designed system, but ensures that the design process continues even after the designer has left the scene. A learner-determined design approach may also put greater stress on the creation of resources, and navigational support so that learners can effectively use those resources. Media literacy comes into play here as well. Part of managing large amounts of available information is the ability to critically evaluate resources in terms of relevance and reliability.

Design and Opportunities for Creativity. This is an area of educational technology that is not dealt with in any systematic manner. The creativity of designers has been discussed, but the engagement of student creativity is generally ignored. This is something that individual teachers have been able to elicit, but no specific principles for the design of creative environments has been created. It is likely that creativity becomes a form of embodied practice as individuals become more and more expert within a shared world of meaning. This suggests that apprenticeship models are likely to lead to creative activity on the part of learners. Enactive constructivism brings the concept of creativity into the foreground: "Context and common sense are not residual artifacts that can be progressively eliminated by the discovery of more sophisticated rules. They are in fact the very essence of creative cognition" (Varela, 1992, p. 252). Context provides the constraints imposed in a given situation. An enactive constructivism depends upon an ability to maintain a history of effective action even while the obstacles or constraints that one encounters change.

The notion of constraint is central to an enactive approach to design. Varela, Thompson, and Rosch (1991) suggest that the prescriptive notion of design in nature be replaced with a proscriptive notion. The argument is that constraining features of a problem can be dealt with in a diversity of ways. The existence of a species depends upon individuals surviving long enough to reproduce. Survival and reproduction are the constraining features that govern the continuation of a species. Within these constraints a diversity of fauna and flora is possible. If, instead of prescribing solutions to design problems, we set constraints within which to operate in the design process, a diversity of solutions becomes possible. If we carry this approach over to our interactions with learners, we open up a space for a creative diversity of response to problems by learners. This should not be surprising because it is not unusual for constraint to be associated with creativity.

Prescription can be construed as oppressive (see Maturana, 1978, Freire, 1973). When I prescribe a series of steps for someone else to follow, I am proscribing an unknown set of alternatives. There is no mechanism for questioning what I have proscribed. When I set constraints by proscribing certain steps, I am providing guidance, but not determining how a goal may be reached. By naming what is proscribed, I am making the proscribed visible and open to question. Proscription does not define a correct route to the solution of a problem making the discovery of new alternatives possible. Learners in such an environment would be constantly challenged to be creative.

Conclusion

I selected enactive constructivism as an alternative to technical rationality as a framework for educational technology because it represents a development in cybernetic theory. This is important because cybernetics has a long-standing relationship with educational technology, providing one of its foundational pillars (see Bopry, 1999). This should give enaction standing in the field of educational technology. The advantage of enaction for the field is that it has the potential to provide a framework within which design can be conducted in a consistently constructivist manner, a manner that places learner agency at its heart. I would suggest that designers ask themselves two questions as they engage in or facilitate design in virtual environments. (1)"In what ways do we account for organizational closure and structural determination in our design?" (2) "What opportunities for structural coupling and effective action are build into our design?"

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2. Create a World, Inhabit the Creation
Imaginary Projections in Symbolic Activities *)

Edith Ackermann

Introduction

Imagine a child playing with other children, and using a stick as a horse: the child jumps around his friends, goes places, feeds the horse, claims that the horse is lazy. In creating this make-believe play, the child is making present the horse, a horse that otherwise would be absent in this child's life. Furthermore, she is not only making the horse present but doing things with it. We say that the horse is ready at hand to convey this idea that the horse is made to participate in the child's playful activities. This scene exemplifies what we call symbolizing: a creation of a lived-in space in which the absent is made present and ready at hand (Nemirovsky and Monk, 1998)

"Creating a lived-in space in which the absent is made present" seems like a good characterization of what symbolizing is all about. Its main advantage is that it doesn't suggest, as correspondence theorists of representation have it, that the objects to be evoked, or represented in our minds need to exist anywhere, nor that they have existed in the past. Instead, the formulation by Nemirovsky and Monk frames the act of symbolizing as a means to sustain a dialog between what is [believed to be] and what could be, between fact and fancy. It highlights that to represent is not merely to describe what exists but to bring to life what doesn't. The authors also remind us that, beyond mere replicating, pretenders often modify outcomes, and subvert the meaning of things. As in improvisational theater, they recast unfolding events, opening up new paths as they play along. Both meaning and coherence emerge as a result of this creative process.

) An abbreviated version of this paper appears in (E. Renk Ed.) Konstruktivismus: Lehren, Prüfen, und Lernen in imaginierten Räumen, Luchterhand Verlag,* 1999. In Press. (German title: Sich einrichten in Fantasie Raumen: Untersuchungen zum Gebrauch von Symbolen).

To Iser too, “the English term ‘representation’ causes problems because it entails, or at least suggests, a given which the act of representation duplicates in one way or another (…) Thus, concealing the *performative qualities* through which the act of representation brings about something that hitherto doesn’t exist” (Iser, 1987,p.217). Iser finds it useful to replace the English term with the German *Darsellung*, which does not, in his view, drag the same mimetic connotation in its wake.

Throughout this paper, the articulation between make-believe and tool or symbol-use is a guiding connection to rethink the aims of representation. I challenge the prevailing theory of representation, often referred to as correspondence theory (Lakoff, 1993), suggesting that there is an a-priori object out there (a territory), that the act of representation duplicates one way or another (map). I show that representations in the sense of *darstellungen* are better thought of as performative acts, i.e., as *fictionalizing techniques*.

Both the enactive and generative aspects of representations are particularly relevant in design activities where an artifact to be built doesn’t exist before the process comes to an end. In design, it becomes clear that the representations needed to generate new forms couldn’t possibly be reduced to descriptions of what’s *out there* – since not much is out there yet! Designers are left with envisioning and engaging forms in the becoming. They build sketches, prototypes, and simulations to generate appearances of these forms. What is true of design is also true of other constructive processes. Most striking in this respect is children’s natural tendency to invent the supports and mediations they need to reach their goals. They do so without being taught whenever the tasks they face lay beyond their mastery. Children’s extraordinary gift as learners comes in great part from their ability to create the stages that allow them to safely project themselves in the unknown. Doing *as if* and playing *what if* are two main techniques they use to achieve this balance.

Nemirovsky and Monk’s notion of “ready at hand” (above citation) further suggests that the props used in pretense need not be [treated by the pretender as] arbitrary tokens or neutral go-betweens. No doubt, the stick that the child “rides and feeds” in her play is a *double* in the sense that it acts on the imaginary horse’s behalf. Yet, this doesn’t imply, again, that the double just mimics its behavior or mirrors its appearance. Signifiers often take on a life of their own, and it is their ability to do so – both *be and not be* what they stand for – in the pretender's mind, that opens the way to their creative use.

We know from research on early pretense that young children's abilities to treat a stick *as if* it were a horse requires some form of decoupling between signifier and signified (Piaget, 1962, Perner, 1993). In other words, a child who uses a stick "as if" it were a horse also knows that it is not "really" a horse. What is less obvious is the idea that decoupling goes hand in hand with its opposite, fusion, for the symbolic transform to be complete. Along with Nemirovsky and Monk, I propose that a child's ability to engage an "ersatz" as if it were the thing itself, i.e., to fuse signifier and signified, is a necessary condition for creative symbol- or tool-use. Fusion is what ultimately gives a signifier its *dramatizing power*. Without empathic projection – engaging double 'as is' – no "lived" experience would be possible. Working out intriguing materials, fictional or real, requires both the creation of a safe place (spielraum) and an occasion for "true" identification.

Using symbols, in this sense, is not just a matter of giving form to ideas, making them tangible and shareable. It is also a matter of bringing ideas and forms to life, by animating them (lending them an *anima*). Treating doubles as if they were [as vivid and vibrant as] the ideas they stand for is what brings the materials engaged in pretense closer to our mind's reach.

Needless to say, the horse itself in kid's enactments is better thought of as an unicorn than as an analog of any existing horse. Like a mythical character, this idealized creature evokes the child's fears, desires, and purposes. And its appearance, the stick, once made to participate in the child's activities, reshapes her original ideas about unicorns. It is, again, the ambiguous nature of the stick in the child's eye, at once double (decoupling), object in its own right (separation), and unicorn itself (fusion) that lends it its evocative and dramatizing powers. To conclude, making the absent present, giving form to ideas, and bringing form and ideas to life are 3 important aspects of the symbolic function.

Pretense: Not a Kid's Thing Alone!

Pretense or symbolic play is not just a kid's matter. Nor is it a privilege reserved to artists and poets alone. People of all ages, stages, and styles engage in symbolic recreations. And they do so in ever more sophisticated ways as they grow older. As Sayeki points out in his paper "Anthropomorphic epistemology," adults, from lay people to scientists, use their creative imagination to project themselves into situations (Sayeki, 1989). They too dwell into their mental constructs as a means to envision, better grasp, reach deeper understanding, and they do so, according to Sayeki, by literally dispatching little pieces of self that they throw into their object of inquiry. He calls these pieces of self "kobitos" (little people in Japanese). Once "in there" via their doubles or extensions of self, people can act out and feel for what their kobitos experience, while remaining physically removed (Sayeki, 1989). They vicariously live through their projected selves' mind's eye.

Obviously, every so often, people also reemerge from the deep waters. They step back and look at things from afar. In their imagination, they achieve this by either changing their stance in the world, byputting themselves in other people's shoes, or by adopting a *god's eye's view*, an altogether removed and all-encompassing view, that miniaturizes the worlds they just inhabited (Ackermann, 1999, Kegan, 1982).

To conclude, in the act of symbolizing, people are both world makers and beings-in-the-world: they at once create their habitats , inhabit their creations, and become "inhabited" by them. In the world of their imagination, fusion (becoming one) and separation (removing oneself) coexist. Both contribute to their personal and cognitive growths.

Grounding Techniques for Mindful Acts

The uses of projective imagination are at play in many forms of symbolic activities, from drawing to scientific modeling, from playful chatting in social virtual environments (VE), to reading and writing. So are our attempts at anthropomorphizing and role-play.

In the following sections, I focus on two aspects of pretense and symbolic play: people's abilities *to dwell into their creations* and their tendency *to fuse signifiers and signified* as ways of becoming authentically engaged. The heuristic role of these grounding techniques is discussed in different contexts. All of the chosen contexts are meant to foster self-directed, exploratory, learning, while at the same time, engaging learners in playful self-projection: from architects' drawing, to children's exploration of mathematical ideas, from people's love affair with social virtual environments, to many digital kids' renewed interest in literacies beyond print.

The contexts, or learning stories, are of two kinds: 1. Handling tools and driving machines, and 2. Exploring / sustaining relation / conversation in digital media. In the first kind, learners interact with objects that prolong their action (prosthetic devices), and / or execute their orders (serves). Serves do things for them, act in their place, provided they are told what to do. In the second kind, learners relate to other people (own minded agents), at once apart and present, and who interact via digital avatars on shared virtual stages. In all cases, the interactivity afforded by responsive artifacts (computers) is used to tap into people's tacit knowledge-in-action, bodily and navigational, and implicit situational wisdom. I show, through examples, that the apparently primitive facet of symbolic activities, empathic projection and fusion, are not just a key to natural learning but can be – and have been – promoted *by design* to help kids learn better. To conclude, I draw some implications for developmental psychology and education.

Dwelling into the Drawing

A few years ago, Bonne Smith, a former student at the School of Architecture, MIT, designed a simple and compelling experiment. She asked some of her fellow students to sketch a floor plan of the house in which they lived when they were 5 years old. She encouraged her subjects to think aloud as they drew, and she audio-taped the process (Smith, 1991). What this experiment revealed, in a nutshell, is that the act of drawing was in itself a world-making technique. Moreover, the draftsman's engagement in the represented "site under construction" was quite anthropomorphic, surely more than one may expect from sophisticated architectural students.

Alternatively becoming dwellers and creators, kids and adults, giants and dwarfs, Bonne's subjects mentally moved in and out of the situation, seamlessly. They projected themselves into the pen-ball "as if" it were a prosthetic device. Moving the pen around made it possible for them to travel along in their mind. The pen became a vehicle of *mental teleportation*. Dwelling in the drawing is what allowed Bonnie's subjects to evoke, revisit, and reconstruct their lost memories.

The most surprising aspect of this experiment is that the subjects' use of projected movement to bring back the "lost" place increased with their level of sophistication as architects. It was much less prevailing among young children and non-architects. This came as no surprise to Bonne, an architect herself, who reminded me that designers often imagine themselves and set themselves in motion in a space *to be*. They do so proactively to envision what that space may be. In her eyes, the experiment confirmed her intuition that people's ability to dwell into their drawing, or use drawing as a trail-making technique (Nemirovsky and Monk, 1998) is one of the expertise that architects develop in the course of their studies and work.

Here are 3 vignettes by Roy, Emily, and Andrew, architectural students whose protocols were rich with imagined movement (Smith, 1991).

Roy: (thinks aloud) "*I am starting from the exterior and I'll be moving in. Here's the car (*draws a car*), the sidewalk moves perpendicularly from the driveway, past three shrubs, and up to the porch and then the front door. Then you move into the front hall like that…*" (traces gesture of moving in and completes by drawing front door and entrance). What's remarkable in this account is that Roy is not the only one to move about. The sidewalk "moves" too, perpendicular to the driveway and past shrubs!

Andrew reconstructed the lived space around the concept of "boxiness" – rectangular container – the shape and content of which he adjusted and refined as he moved through the virtual house. "*This house was a breadbox. Just a good old American colonial* [draws rectangle*], brick box. Do you enter in the middle? OK* [draws entry]. *So you enter and there is this staircase* [draws stairs middle of rectangle*]. Yeah, that's pretty much the main focus when you come in* [Andrew then proceeds to locate different spaces around the stairs and adjusts sizes by invoking action in and around them]. As he mentally moves into the salon

"Wait? Can you walk behind the couch? the door? [He reaches out to grab an imaginary doorknob to determine the door swing].

Emily's use of imaginary projection was different yet. She spoke about the visual fields, or "perspective," that unfold before her eyes as she walked through space in her mind: the view down the main street, the view of the façade. Holding these perspectives in mind helped her restitute otherwise forgotten adjacencies and directions. Emily: "*…when you go up the stairs, on each side you have…two regular doors that you can open, that you can push into…first thing you see is the reception desk. You'll have a lot of, I think there's an old sofa here…"*

Note that all the subjects used the present tense in their accounts, which reinforces the idea that, in their minds, they were "really in there", as they were when they were kids.

Drawing Shapes by Driving Turtles: A Microworld for Building Geometric Figures.

Our bodies hold quite a bit of knowledge about space in their movement. Yet, much of this knowledge remains tacit, hidden in the beholder's habitual activity and experience. It needs to be brought to the mind's reach. One of Papert's greatest insight in designing Logo-based Turtle Geometry, a software environment for building geometric shapes, was to tap children's knowledge about their own movement in space, and to use this knowledge as a lever to help them explore spatial relations and transformations.

In turtle geometry, children "instruct" a computational creature, represented by cursor on the screen or a turtle, a mechanical toy, to draw shapes by moving in prescribed directions by prescribed amounts. Kids communicate with the turtle using a programming language that it can "understand". A turtle can be made to move by typing commands at the keyboard. FORWARD 100 makes the turtle move in a straight line a distance of 100 turtle steps of about a millimeter each. Typing RIGHT 90 causes the turtle to pivot in place through 90 degrees. Typing PENDOWN causes the turtle to lower a pen so as to leave a visible trace of its path while PENUP instructs it to raise the pen. The commands and procedures available to drive the turtle are fairly intuitive to the child. They are also carefully chosen to enable the generation of many mathematically relevant and intriguing figures in space.

The guiding principles behind Turtle Geometry are simple and very much in tune with our views: Papert's turtles become extensions of self that the child controls using words. Giving directions – remote driving – encourages the child to reflect upon her own know-how and to express it precisely enough so that the machine can carry it out. "In teaching the computer how to think, children embark on an exploration about how they themselves think" (Papert, 1980, p.19)

More important, Papert's turtles are designed to be "egocentric". Directions are given in reference to a turtle's position and heading and not as a function of some external reference system (xy coordinates). This requires that users put themselves in the turtle's shoes, literally, to figure out where it wants to go next. The syntax of Logo further provides a rich toolkit to assemble basic available operations (like rotations and translations) in interesting and surprising ways. Using computational tools and object responsiveness offers instant feedback, which helps sustain the interaction.

In *Mindstorms,* Papert (1980) stresses the role of what we call mental teleportation: "A turtle has a position and a heading. In this, it is like a person or an animal or a boat (p.55). Children can identify with the turtle and are thus able to bring their knowledge about their bodies and how they move into the work of formal geometry (…) Drawing a circle in turtle geometry is body syntonic in that the circle is firmly related to children's sense of and knowledge about their own bodies. It is ego syntonic in that it is coherent with children's sense of themselves (one could say children's point of view or stance in the worlds" (p.63).

Swinging a Graph: A Microworld for Body Syntonic Maths

Other learning environments have been designed to facilitate the articulation between world-making and world-dwelling. A case in point is the use of a *motion detector* by researchers at TERC (Technical Education Research Center), Cambridge MA, to help children learn about graphs. The display was designed by Nemirovsky and his team to augment children's control and understanding of graphical representations of mathematical variations over time (Nemirovsky, 1998; Tierney, Nemirovsky, Wright, Ackermann, 1993). I call the micoworld "swinging a graph" because, like Papert's turtles, it uses body motion as a vehicle to generate and control shapes. This time the activity is mediated by a motion detector, and the shape to be "drawn" is a time / graph on a computer screen. Other mediations will be added to allow progressive removal from a merely sensori-motor dance with the graph.

The motion detector used in these studies consists of a small button, the position of which is measured, of a sensor or electronic eye (also referred to as tower), and a computer. In interacting with the device, children hold the button or pin it on their shirt and move their bodies. They can also place the button on a moving object such as an electric train. The electronic eye (tower) measures the distance that separates it from the button at each moment in time, and outputs a graph that plots positions over time on the computer screen. Thus, by moving the sensitive button back and forth in front of the "eye," children can impact the graph's shape in real time: shapes vary as a function of the direction and speed of their, i.e., the button's, movement.

Kids' first encounters with the motion detector are almost exclusively experiential. As they move back and forth with their button, [they realize that] the shape of the graph varies in reliable and somewhat principled ways. Very soon, though, the children learn to identify and to describe some of the changes they provoke. They tell us, for example, that as they move closer (to the tower) the graph goes up, and as they move away it drops; that if they move faster it becomes steeper, and if they slow down it flattens out. Sooner or later, kids also become interested in "swinging" very specific graph shapes. This requires that they understand, at least in action, *what* causes a graph's specific response. In doing so, they come to learn, for example, that they can't draw a circle or a square because the graph on the screen never goes backwards.

As in Turtle Geometry, mediations have been introduced to help children move away from regulation-in-action to reflection. One of the mediations proposed was to remove the distance-sensitive button from the child's body, and to place it on the "face" of an electric train. The train was placed on a straight track in front of the motion detector. The child has now to move aside and to drive the train using a rotating knob, or dial. A next step in the mediating process, which was not explored at the time, would be to let the kids instruct or program the train, digitally. This would complete the cycle between moving one's own body, driving the train by hand using an analogical dial, and programming the train or give it a set of instructions.

As in Turtle geometry, the purpose of the display is ultimately to facilitate the passage between direct and mediated action, or action and reflection. Switching back and forth between *doing it oneself* (engaging one's body) and *giving instructions to "other"* (in this case instructing some responsive artifact) is what brings about deeper understanding (either about geometric or arithmetic operations). In both cases, the dynamic properties of interactive tools are used to tap into learners' knowledge-in-action, while additional mediations are offered to favor the passage from reflection-in-action to reflection-on-action.

Reflection-without-action (do it all in the head), eventually emerges after a great deal of massaging, after many mindful explorations, a lengthy process indeed. No doubt, disembodied thinking, once achieved, opens the way to entirely new forms of reasoning, otherwise impossible (like systematically operating in a world of possibles). Yet, abstract thinking itself would fade away over time if it were not constantly re-grounded. It can't ever substitute / erase that which made it possible. It can only complete it, compose with it, and co-evolve. In Piaget's words, schemes need to be alimented all the time to survive.

Both Papert's turtles and TERC's motion detector are designed to help children think of themselves as "doing science" when they are doing something pleasurable, involving their minds and their bodies (Papert, 1980, p 68). Children learn because they are offered an occasion to use their own experience as a lever to actively explore mathematical ideas.

Virtues of Virtual

In the following sections, I explore some new forms of literacy that emerge from kids' spontaneous interest in – and mastery of digital technologies. These *literacies beyond print* pave the way for entirely new genres of collective story writing, and offer fertile ground for rethinking existing approaches to teaching reading and writing (Ackermann, 1993). Of particular importance in this regard is a concept that Ong refers to as "secondary orality," an entirely novel form of written dialog sustained by computational media that depend for their existence and functioning on writing and print (Ong, 1982). I focus the discussion on MUDs and other text-based social virtual environments.

Social virtual environments (Internet Relay Chat, Alphaworld, MUDS) can be thought of as digital stages for improvisational theater, or psychodrama. They are fictionalizing devices in Iser's sense. In MUDS, [1] for example, "players encounter other players as well as objects that have been built for the virtual environment. MUD players can communicate with each other in real time, by typing messages that are seen by other players. Some of these messages are seen by all players in the same "room", but messages can also be designated to flash on the screen of only one specific player" (Turkle, 1995, p. 181). VE inhabitants, or avatars, are extensions of the human players. Their appearances and modes of interaction are mostly created and staged by the players themselves, in dialog with others.

What's particular about Social Virtual Environments, as compared with other playgrounds for pretense, is the intricacy of the connection between users and their avatars, the immediacy and unpredictability of other player's response to one's virtual appearance, and the hybrid nature of the world itself, neither representation nor reality. As Turkle points out, VE-mediated exchanges deeply change the nature of our commitment to others, as well as our sense of selves. MUDs provide a stage for anonymous interaction in which players can choose a role as close to or as far from their "out of MUD self(ves)." (Turkle, 1995, p.180)

In social VR, as in good improvisational theater, players do not recite scripts that are written by someone else. Instead, they are their own playwrights, choreographers, and actors. As in pretense play, staged events are both lived in and acted out. Players make scenario unfold and drama come to life. Dwelling in social VE allows them to mediate their experience – live their lives on the screen – while remaining mentally engaged. It is the make-believe nature of the virtual space created, in conjunction with the truthfulness of the thoughts and

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[1] Dungeons and Dragons was popular game in which a master created a world in which people take on fictional personae and play out complex adventures. The term "dungeon" persisted in high-tech culture to connote a virtual place. So when virtual places were created that many users could share and collaborate within, they were deemed multi-user dungeons, or MUDS, a new kind of social virtual reality, and the term MUD and the verb MUDding have come to refer to all of the multi-user environments. Some MUDs use screen graphics or icons to communicate place, characters, and action. Others rely entirely on plain text.

feelings experienced through dialog with others, that make for the power of VE enactments.

Attached to their avatars like a puppeteer to her string puppets, players act and feel through them. Virtual string puppets are both built by the puppeteer and brought to life by her. They are masks for idealized identities, allowing players to appear in a desirable light and hide those aspects of self that are not thought of too highly. Like Sayeki's kobitos, digital avatars are extensions of self that can be launched into the VE and made to act on one's behalf. It is the creator's strong connection / identification with their avatars that allows them to vicariously experience what they "go through". More easily than traditional puppet-theater, players can endorse multiple personae and launch them into different habitats at the same time.

People's ability to put on the hats of multiple personae is not new in itself, and has its off-line equivalents in adult psychodrama and face-to-face role playing games. What's different in VE, is the ubiquitous quality of self-appearances. It's like being in two "bal masqués" at once or maintaining parallel streams of conversation. Along with Turkle, I think that digital fictionalizing tools, enriched MUDS of sorts, can be used to help people, young and old, work out intriguing mental events, foster projective imagination, and construct their inner and outer worlds.

To summarize, in VE, players can live things at a distance and get in touch with them at the same time. They can take risks on relatively safe ground. Using avatars allows them to remain anonymous, filter their appearance and control their level of engagement. Last but not least, the opportunity to come back again and again, changing face, and reconfiguring habitats (changing props) allows them to work out different versions of intriguing scenarios over extended periods of time. As in pretense, MUDers vary outcomes and rearrange story elements. Yet, as in psychodrama, they interact with others for good. What's unique in VE is that players can engage multiple dramas at once, or take on multiple hats in a same drama.

Implications for Education – Digital Kids and Emerging Literacy

The passage from orality to literacy is a difficult passage for many kids – not just for children who grew up in dominantly oral traditions or in households where books are absent. Closer to home, digital kids who zap, chat over the phone, and surf on-line – while papa and mama read in the salon – find it increasingly "boring" to be forced into literacy via the world of print.

From a child's perspective, it is quite legitimate to wonder, when enticed into the world of print: Why should I write it when I can say it? Why read it if I can be told? From an adult's perspective, things look different of course. Adults know that access to literacy fosters personal and societal growth, and that people's ability to put the word on paper has paved the way to entirely new forms of reasoning, otherwise impossible (Olson, 1994). Adults, indeed, become upset when their children question their passion for books, or challenge their convictions on the liberating effects of literature, so often identified with literacy (Ackermann, 1999).

Ong's concept of secondary orality sheds new light on the debates opposing printophiles and netizens on what it means to be literate and how to help kids become so: Should a child be a producer consumer of printed words? Can electronic writing, sketching, often referred to as infographics, enrich youngsters' rapport with the written word?

To Ong, the passage from orality to literacy, while bringing about priceless gains, also entails deep losses, often ignored by educators, researchers, or parents who grew up with print (Ong, 1982). Writing is a powerful tool of distancing, but separates author from audience, audience from the site of the plot, and word from voice. Print can be silent and cold. It casts speech in stone. Speech, on the other hand, is an integral part of human performance, and punctuates a locutor's action as it unfolds (in situ). Speech bridges what is said to who says it and who says it to how it is voiced. Speech allows locutors to sing their tunes, to respond to their audiences, to be actors embedded in the pragmatics of conversation.

Children's own infographic productions are more often than not hybrids, reflecting their natural tendency to cast the world in "a hundred languages" (Malaguzzi, 1987). In a single production, that is, kids don't hesitate to pick whichever medium conveys their ideas, with little worries for bastardization.

Research by Bruckman (MOOSE Crossing) and Umaschi Bers (SAGE) shows that text-based and text/voice-based environments for distant-chat, storytelling and role-playing can be designed to support what Ong's calls "secondary orality". These modalities can be used to help reconnect authors to their audience, and bring everyone back to the site of a plot. Educational materials like interactive storybook reading and big books, proposed by the emerging literacy movement are precursors to digital storytelling environments. The question remains: are such hybrids bridges or barriers to children's re-awakening to literacy? And what are the costs of writing to talk?

MOOSE Crossing: Say it in writing on the Internet

In text based MUDs, people converse, exchange gestures, and express emotions in real time, yet they do so in writing. They describe places using words. They use typographic conventions known as emotrons to replace physical gestures and facial expression[2]. Onomatopoeic expletives and relaxed attitude toward sentence fragments and spelling errors suggest that this new writing is somewhere in between written and oral communication. Note that while most adults deplore youngsters' increasing indifference to spelling errors, kids nowadays learn to spell in new ways. Like many of us, they set the spell checker of their word-processor on "signal" mode and fix underlined words as they write along. Sometimes they find the right spelling by themselves. Sometimes they look it up. More often than not, they learn quite a bit, and effortlessly, as a result of using a spell checker.

"Nine-year-old Lynn loves to write", says Amy Bruckman who designed MOOSE Crossing, a text-based VE for kids on the Internet. "Over the last year, she has built a snake that wiggles, a bubble blower that blows many different kinds of bubbles, a doll that complains when you drop it, a plant store…All these objects are created out of words and programs. Lynn proudly shares her creations, and talks about them, with other children from around the world" (Bruckman, 1998). The experiences of Lynn and other two hundred children who participated in the MOOSE Crossing Project challenge our traditional notions about literacy. In this environment, words and programs are intimately connected. Words are used to describe things, and as commands to trigger interesting event. Written words are no longer scribbles on paper, an inert trace that "doubles" speech – and sometimes feels redundant because one already knows how to speak it. Instead, words are keys to trigger actions and events.

[2] For example, ☺ indicates a smiling face, ☹ indicates a sad face , ☺ indicates a wink.

While learning to read and write in print is mostly a solitary activity, Children's experiences on MOOSE Crossing take place in a web of social relations. Their writing is both multi authored, ephemeral, and a string of verbal commands to transform the world. All happens *in situ.*

SAGE: An Interactive Storytelling/Writing Environment

In oral traditions, the conditions of production (the storyteller telling) and the conditions of reception (the audience listening) interact with one another to shape an unfolding narrative. In the realm of speech, young children learn to master the art of conversation with great ease. However, only after several years of learning to read and write do they become aware of the need of adjusting their written texts to their audience. Umaschi Bers hopes that hybrid narrative media combining text and speech may help children recover some of the pragmatic dimensions of story-building that got lost with literacy. Umaschi Bers designed SAGE (Storytelling Agent Generation Environment), a text-based construction kit for children to create their own wise storytellers to interact with by telling and listening to stories.

In SAGE, a digital puppet show of sorts, children are the users as well as designers of their storytellers. They interact, through a text-to-speech conversation, with existing characters (with their repertoire of stories). They can also create their own characters. In order to create a believable storyteller, children need to situate the character in a context. They need to plan what it will say, what idioms it will use, give some background information about its persona, create the underlying conversational structure and set the conditions in which the exchange of stories will happen. This structure varies according to the role of the storyteller. For example, says Umaschi Bers, "if the character is a Jewish rabbi with a repertoire of Hasidic stories, the conversation involves some religious or existential questions and the teller has a respectful attitude. If the storyteller is a famous basketball player (as the one built by a ten year-old boy) the nature of the encounter is very different".

SAGE is an example of a computational storytelling environment that facilitates the integration of pragmatics and literacy. In order to work with SAGE, children create, interact with, and stage storytellers always situating them within a conversational context. This is a useful exercise for children to start understanding what are the shared and different dynamics that rule the realm of communication.

To summarize, text-based storytelling and role playing environments, as well as environments that facilitate switching from text to voice (ex: type words and get sounds back) and use of text as commands (ex: type commands to teach or monitor a digital “turtle”) can be instrumental to re-awakening kids to literacy.

Conclusions

Fusion and separation are two poles of a continuum that are too readily opposed or placed in a developmental sequence. It has been our view, in this paper, that the abilities to put ourselves in another person’s shoes, or mind, i.e. to change perspective and switch roles requires both fusion and decoupling, being simultaneously “there” and “not there,” embedded and disengaged. Fusion doesn’t preceed decoupling, it accompanies it. Playing “what if” or the ability to pretend (establishing a dialog between what is and what could be) is the means by which children as well as adults achieve the difficult balance between getting immersed and emerging from embeddedness. Play is an important aspect in human learning, from identity building to constructing knowledge about the world. Erick Erickson defined play as a toy situation that allows us to reveal and commit ourselves in its unreality. Play operates within a transitional space (Winnicott, 1989), halfway between self and world, distinct from self yet under its control and, above all, more resilient that the world, in which the child can take safe risks.

Throughout this paper, the articulation between make-believe and symbol-use has been a guiding connection to rethink the aims of representation. I explored the ways in which doing *as if* and playing *what if* inform people’s conversations with – and through –artifacts. I discussed the benefits of children and adults’ abilities to dwell into their symbolic creations and to treat symbols as objects in their own right. To situate my argument, I presented a series of learning stories or learning environments that support both world-making and dwelling into one’s world.

By way of conclusion, let me offer two suggestions that I wish were taken more seriously by developmental theorists and educators.

The first suggestion is that people's abilities to fuse signifiers and signified and to treat signifiers as interesting objects by themselves are two powerful heuristics in creative symbol use. Their role in knowledge construction and scientific activities has been generally undervalued for being primitive or generative of confusion. Their role beyond poetics is worthy of more study. A second suggestion is that the significance of enactive forms of representations, from pretense play, or *simulacre*, to simulations, be included in the study of symbolization and granted a new place next to language.

Note that the French word *simulacre* and simulation sound very much alike. In both cases, a scenario or sequence of actions is being played out, which has been de-coupled from its usually associated contexts. What's more, scenarios are not just described, as in writing or drawing, but they are actually run, or executed, as by a calculator. From objects-to-think-with (Papert, 1980) they become operations embodied, and people tend to relate to them as partners, with whom they share a task (Ackermann, In press).

The difference between the two is the medium through which the performance is run. In *simulacres* and rituals, the medium is a human actor, or an actor's extension. In simulations, the medium is a human-made artifact, machine or program, that runs a sequence of operations on your behalf. Simulations need not mimic something that exists. Their particularity is to execute operations that are only posed in language or notations.

At a time when computational objects make it easy to run programs, model dynamic interactions, and simulate behaviors, people's ideas on what modeling is all about are deeply changing. So are their ways of relating to existing modeling tools. More than in the past, performance and simulation are granted a new place alongside language. It's time for us, researchers in cognitive development and educators, to catch up and revisit our own views.

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3. Social Processes and Knowledge Building in Project-Based Face-to-Face and Networked Interactions

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Introduction

Approaches to learning and instruction have, for sometime already, put emphasis on contextual and situational factors as well as social interaction and collaboration between individual learners. It is argued that what students learn in school contexts depends on the activity they are engaged in (Greeno et al., 1998). This has led to efforts to create such learning environments that give the students possibilities to participate in authentic, meaningful and purposeful activities as well as joint problem solving. Project work is seen as a way to promote high-level learning by engaging students in real scientific work and discourse. Also, some good results have been gained by facilitating joint knowledge building and project work in technology-based environments (Scardamalia & Bereiter, 1996; Edelson, Pea & Comez, 1996).

The benefits of collaboration have mainly been studied in face-to-face situations where high-level talk between students has been seen important for promoting learning. Still, little attention has been paid to other social processes and factors related to the learning environment, which allow or restrict some types of talk to develop in the first place. New advanced technology-enriched environments put us also in to a new situation where interaction takes place in the network and is no longer tied in one place or time.

This study aims to investigate what kinds of modes of group interaction are present and dominating in different project-based environments. Our main focus is on the collaborative processes of learning, particularly on describing and specifying the social and contextual factors that support and hinder joint knowledge building. The study described in this paper is a part of the research project called CATO (Collaboration and Authenticity in Open Technology Enriched Learning Contexts), which seeks to promote the integration of new technologies in open, authentic and collaborative learning contexts.

Theoretical Background

Recent research on learning has emphasized the positive effects of collaboration on learning (e.g. Light et al., 1994). Nevertheless, ethnographies of classroom life reveal that effective student collaboration is strikingly rare. Collaboration is seen as construction of shared understanding through interaction with others (Dillenbourg, 1999; Littleton & Häkkinen 1999) where commitment to shared goals and problem-solving is seen as an important prerequisite for learning (Roschelle &Teasley, 1995). Collaboration is thought to promote learning because it helps students to become aware of their own thinking processes as they share different viewpoints in conversation. Collaborative conversation supports joint critical thinking by motivating students to explicitly explain their thoughts and to evaluate other students' thoughts as well. Thus collaboration must be differentiated from co-operation where the learning task is divided into sub-tasks which individuals complete alone (Linn & Burbules, 1993).

Many studies of collaborative learning have concentrated on studying group discourse. For example, Mercer and Wegerif (Mercer, 1996; Wegerif & Mercer, 1997) have tried to identify different interaction features in students' joint discourse that are related to high-level understanding and learning. These studies differ from more traditional linguistic studies in that they focus rather on the process of building and sharing knowledge than just on measuring specific linguistic characteristics of talk. Mercer and Wegerif have found that critical reasoning is typical of talk that promotes deeper understanding and learning. According to Mercer (1996) this talk, that he calls *exploratory talk*, occurs when the participators engage critically but constructively with each other's ideas. In exploratory talk statements and suggestions are offered for joint consideration. These are then challenged and counter-challenged with justifications and alternative hypotheses. In exploratory talk knowledge is made publicly accountable and reasoning is visible. Similarly, Mason (1998) found that students constructed more advanced knowledge by reasoning and arguing collectively. *Cumulative* and *disputational talk*, then again, are types of talk that do not promote joint critical problem solving (Mercer, 1996). In cumulative talk the participators build positively but uncritically on what the other has said, thus constructing common knowledge by accumulation. Repetitions, confirmations and elaborations are typical in cumulative talk. Disputational talk, for its part, is characterized by disagreement, competitiveness and individual decision making. There are few attempts to solve problems together or to offer constructive criticism on other people's suggestions.

One can agree that a prerequisite for high-level collaborative learning consists of the above-described ideal learning situation, where different perspectives are critically discussed and reasoned. While much of the research on collaborative learning has concentrated on revealing these discursive features of joint interaction, other characteristics influencing interaction and learning in the context have received less attention. For example, the task structure has an impact on joint learning. Unlike fact-seeking questions, open-ended and discovery tasks (Cohen, 1994) and tasks that involve abstractions enabling negotiation (Schwartz, 1995) have been seen to promote joint problem solving and reasoning. Also Dillenbourg (1999) has argued that to be able to truly collaborate, the participators must play symmetrical roles in conversation. They must have equal opportunities for participation and their level of knowledge must be broadly the same. When the knowledge level among participants is very different, it leads to different statuses and roles in the learning situation. These different statuses and roles can have very profound effects on learning (Richmond & Stirley, 1996; Cohen, 1994; Linn & Burbules, 1993). Cohen (1994), for example, have found that general academic status differences may affect interaction and influence so that the power order of the group reflects the initial differences in status, even if the task does not require the academic ability in question. The academic status is the most powerful of the status characteristics in the classroom because of its obvious relevance to classroom activities.

Technology-enriched environments create also new possibilities for building joint understanding. Computer technology can support collaborative learning and construction of high-level understanding by making thinking visible and public. Different modes of knowledge representations can operate as reference objects that help students construct shared understanding (Enyedy, Vahey, & Gifford, 1997). Also, the possibility to share the cognitive load between students and by means of technology has importance for learning. Recent research of learning environments has emphasized the possibilities of shared virtual environments in promoting social construction of knowledge (Scardamalia & Bereiter, 1996; Pea, 1993). There are attempts to build network-based systems that would support shared inquiry, communication and knowledge-building with project members through shared workspaces.

Interaction in a network also brings along new features for collaborative interaction. It has been suggested that during network interaction, for example, the emphasis is rather on solving cognitive conflicts than on solving emotional or social conflicts typical to face-to-face interaction. Furthermore, it has been suggested that network interaction helps to support reflective thinking, because students have more time to think and form their thoughts than in face-to-face situations. But to find out more about the nature of collaborative learning processes and what promotes collaborative knowledge building, different features affecting learning must be studied *in the context* of the joint activity, i.e. with relation to and in the form they occur in different learning environments.

Aims

The study aims to investigate how knowledge is constructed and shared in two project learning environments of different kinds. The purpose is to gain better understanding on those social and contextual factors that support or hinder collaborative learning during face-to-face and networked interaction.

The more specific research questions are as follows:

- What kinds of social construction processes of shared knowledge are typical in face-to-face and in virtual environments?
- What is the nature and quality of conversation and how does it relate to the understanding of domain knowledge?
- How do social and contextual factors interact with the different modes of building and sharing knowledge?
- How can the support mechanisms built into shared workspaces and communication tools help the construction of knowledge in virtual environments?

Method

Research design

The research is realized in two phases. The aim is to study collaborative processes in different kinds of project learning environments.

SUB-STUDY 1: The first project followed the scientific inquiry typical of natural sciences, including scientific experiments and observations, data collection, reliability judgements on the experiments and observations as well as conclusions and interpretations. The aim of the project was to examine the phenomenon of autumn tints in forest caused by frost. It is a typical natural phenomenon in which the leaves of deciduous trees change colors in autumn. This project was related to a broader framework examining the phenology of plants. Small group of four ninth-grade students worked on the project 2-3 hours per week and the project lasted three months during a five-month period. This sub-study took place during the years 1997- 1998.

SUB-STUDY 2: The second project is a history project which is carried out in an advanced technology-supported FLE setting (Future Learning Environment) designed for facilitating collaborative knowledge-building among students. FLE is an educational groupware tool. The environment provides students with both personal and shared workspaces for building their own knowledge. Collaborative knowledge-building is supported by means of various communication tools as well as by tools designed for joint planning and monitoring of a learning project, which provide a graphical representation of the dynamics and development of the project. In this FLE setting seventh-grade students of two different schools are participating in a learning project in the form of a role game on imperialism. The other school is Great Britain and the other one is India. Students plan themselves the roles they want to play. In classrooms students are also participating in small group working. The FLE modules the students use in this history project are called *my desktop*, *knowledge building* and *jam session*. The desktop opens up when students log into the FLE environment. In their personal desktops the students can store various documents in the form of text, video, graphics etc. This space can also be used in sending messages to other FLE users. Knowledge building is a shared space to discuss different topics. It supports higher-level knowledge processing, and directs into presenting one's own thoughts and conceptions as well as to shared critical reasoning. Before participating in discussion students have to choose a 'line of thinking' – i.e. a problem, a working theory, deepening of knowledge, a comment, a metacomment, conclusions, help - for every discussion message they send, which specifies the meaning of the message. Into jam sessions students can bring different versions and sketches of texts, pictures, etc. and to work and elaborate on them together while the original idea stays in view. Jamming helps to make thinking visible by displaying different ways of realizations as well as contradictions and problems of different versions. This sub-study has just started and is still partly in the planning phase. It will continue more intensively in autumn 1999 after students' summer holiday.

Data collection

Discourse and knowledge construction in project-work settings can be seen as temporarily constructed and cumulated activities, which requires a long-term follow-up approach instead of examining isolated learning sessions. Therefore, data will be collected by videotaping students' interaction situations throughout the projects. Different documents and traces of communication produced in shared workspaces and discussion forums in the FLE environment are also collected. In the first sub-study the students and the teacher were also interviewed before and after the learning project. In the second sub-study all students are to fill in a questionnaire before and after the project. This time the students will not be interviewed, however, because of the large number of students (n=40) participating in the project. Quantitative data about the nature, time and volume of participation as well as about the distribution of communication among the users will be collected from the FLE. Pre and post measures of students' knowledge about the subject matter will also be conducted in the form of essays in the history project.

Data analysis

In the first sub-study no small-group interaction took place until at the report-writing phase, where the students made conclusions and interpretations based on prior experiments. So, even though the whole project was recorded on video and audio tapes, the focus of the data analysis was on small-group interaction that took place at the report writing phase. Verbatim transcriptions of students' talk were made from the video and audio recordings. Also nonverbal activity; who did what, who talked to whom etc., was transcribed. From the transcribed data first the quality of the talk and the symmetry of knowledge-based roles were analyzed. In analyzing talk Mercer's (1996) typifications of students' joint discussion were utilized in addition to specific features arising from this data. Mercer's typifications are shortly presented in the section on theoretical background. One assumption made in this study based on literature was that the participators' symmetry of knowledge promotes high-level discourse. So, also the symmetry of roles and statuses was analyzed from talk. Role symmetry refers to the participation or/and knowledge symmetry of the participators. Based on the quality of the talk and on the symmetry of roles, different descriptive categories were formed to represent different ways of sharing and building knowledge. After forming these categories, the data was further analyzed and processed to find out what social and contextual features were involved in these patterns of interaction. In order to understand the features affecting the learning situation, transcribed interviews and field notes made during the report writing situation were also used, in addition to the video transcriptions. In the second sub-study the main interest will also be in analyzing different processes of interaction as well as different contextual features involved in the different modes of interaction.

Results and Discussion

Results and discussion of the first sub-study

The aim of this study was to investigate how knowledge was constructed and shared during project-based face-to-face and networked interaction. The first sub-study took place in the context of scientific inquiry and the second sub-study deals with the context of a history-related role game in a virtual environment. Joint critical reasoning described in many (e.g. Mercer, 1996; Mason, 1998) was seen as a prerequisite for collaborative learning. In the first sub-study four patterns of interaction were identified which differed according to the knowledge symmetry and quality of talk evident in the situation. A collaborative learning situation was achieved in the context of *critical joint knowledge building,* where students had equal roles and where the task supported reasoning. In this context students solved problems together and negotiated a shared meaning and understanding about the subject in hand by critical reasoning. But the prerequisites for critical joint knowledge building included also motivation and engagement to understand, close relationships between the students, prior work experience together, and the teacher’s timely scaffolding. It was typical of, and also essential for, these collaborative learning situations that the students were resource interdependent in a reciprocal fashion (Johnson et al. 1990). This was partly due to the fact that in the critical knowledge building situation the task was a real group task in its nature (Cohen, 1994). Interdependence in this context meant that the students could not have understood the subject in hand by reasoning alone. In other words, they were truly sharing cognition.

In the case of *uncritical joint knowledge sharing* students' talk was very much inclined to agree and uncritical, although they were acting at the same level of knowledge. Uncritical knowledge sharing was similar to what Mercer (1996) calls cumulative talk. Students' motivation and dedication to really understand the subject matter was not very high in these instances. One reason for uncritical joint knowledge sharing can be found from teacher's questions, set for guiding the report writing, which did not promote reasoning. For example, the students were at many times cumulatively recalling their shared experiences. But the task structure did not always explain students' uncritical involvement. Uncritical joint knowledge sharing occurred also when they were answering questions that were likely to support reasoning. In that instance it seemed that the predominant norms and expectations in the group supported hasty, unreflective decision-making. The students seemingly felt a pressure to go along rather than consider any alternatives. Still, it seems that uncritical knowledge sharing needs a positive relationship and some group commitment in order to take place.

Tutoring was close to a high-level collaborative learning situation, although the students had asymmetrical roles. Students were engaged in building the advisee's knowledge and understanding and discussion was of a high level. Their talk was at a high level in the sense that the tutor explained her thoughts so explicitly that the advisee was able to reach an understanding on the matter. In contrast, in a *leader-centered situation* the talk did not reach a very high level because the leader presented her point of view as the 'truth' which was not explicitly explained or substantiated. Leader-centeredness was common at the beginning when the group was newly formed and the participators were not committed to shared knowledge construction. In the leader-centered and tutorial situations the task structure itself did not seem to have much influence on the interaction. Rather, it derived from more permanent, real or alleged, asymmetry in knowledge.

Collaboration, i.e. critical joint knowledge building, was rare in this data. The students produced mainly descriptive information instead of finding deeper explanations for the phenomena under study. So, the most common pattern of interaction was uncritical joint knowledge sharing. Songer and Linn (1991) have found that students often regard scientific knowledge as static rather than dynamic or progressing and open to revision. So, the school subject in itself may have created a restrictive norm to students' working. Also, it seems that the more general school culture, as well, supports the idea that knowledge is static. Tests and teaching in the form of knowledge transmission are characteristic of this kind of school culture. This, for its part, supports memorizing instead of reasoning. So, when the teacher gave the students questions to answer, the students were more inclined to recall or guess the right answers than to attempt to understand or learn more about the matter. Uncritical joint knowledge sharing represents well the prevailing school culture. When the aim is not to learn but only to do the task, all answers are accepted without hesitation, in order to complete the assignment. So, it is not even necessary to recall the right answer as long as you can give some answer.

One reason for uncritical recollection of the laboratory results was that joint working did not take place until at the report writing phase. It could have been beneficial for the students' learning had they been working as a group from the beginning of the project. It would have been natural, while working in laboratories, the students to discuss and compare their findings. Now when the comparison of experiences took place at the report writing phase after two months since the experiments, it was no wonder that the students had little motivation to discuss or clarify their conception about the phenomena. The experiments seemed to offer the students separate entertainment without any deeper integration to the overall goals of the learning project. From the perspective of situated and socio-constructivist learning, the learning activity is seen as an essential determinant of learning. For example, project working is seen as a way to promote high-level learning, as it engages students in real scientific work and discourse (Pea, 1993). But if the scientific discourse takes place *after* the scientific work is done and not *while* it is done, there is no real context for this discourse. As a consequence, students who are not used to write scientific reports write the report as they do most of their school assignments, that is, by memorizing facts and describing events instead of reasoning deeper explanations for the phenomena. Project work should be based on and seen as a collaborative process, where students also from the beginning can share their thoughts and ideas, and in so doing construct their shared knowledge.

Based on the results of this first sub-study it can be concluded that collaboration is very much context related. The quality of social interaction, and thus collaboration or non-collaboration, changed all the time depending on what were the influential factors in the social contexts at the given time. Thus, students' actions and understanding were based on the context of the actions and conceptions of the other students participating in the activity (Shepardson, 1996). Because of the situational nature of learning, the ideal circumstances for learning are very difficult to gain in schools. A teacher cannot possibly consider all the factors involved in the learning situation. However, with the help of current research teachers may become more aware of some of the factors affecting learning in social interaction, which enhances their ability to help their students get closer to a high-level collaborative learning situation. Group work should not, therefore, be seen as a method that automatically produces good learning. In good group work there must be real social (verbal) interaction. For example, in group work students sometimes divide the learning tasks and each group member completes one of the parts without sharing them with the others at any stage, so that there is no real social interaction involved in this divided work. Mere existence of social (verbal) interaction, as such, does not guarantee good learning result, either. In this study the data covered about four hours of verbal social interaction, but genuine collaboration was like a drop in the ocean. So, you also need to know about the prerequisites involved in high level social interaction and collaboration. The nature of the task, group dynamics, lack of teachers timely guidance, and long span of the project were all factors that on they own behalf affected profoundly on the quality of students' interaction and learning in this study.

In light of these results, it can be said that in the first place group work is not beneficial in all cases. If the task is just to dig up the right answers, why not do it alone? Doing it individually guarantees that all get the needed information, which is not the case when, for example, someone is pushed aside or withdraws from the group work situation as a result from inappropriate grouping of students, as happened in this study. Unfortunately, many projects and group work situations in schools are based on tasks that are not really group tasks but tasks that individuals can do as well or even better when working alone. Also, group work has to be based on voluntary participation. There are individuals who do learn better by working mentally alone. This does not mean that anyone should be left alone and without opportunities for better learning and sharing cognition. More attention should be paid in guiding the students not only toward the cognitive goals but also on how to work in a group and as a group, and helping them create an open communicative atmosphere.

Preliminary observations of the second sub-study

As the second sub-study has just begun and is still partly at the planning phase, there are no results available as yet. Nevertheless, this chapter presents our preliminary observations on the student project, which are based on the restrictive and supportive factors of collaborative learning we found in the first sub-study.

Lack of motivation was one of the central problems at the report writing phase of the first student project. In the upcoming history project the role game will be one way to activate and motivate students to commit themselves to the history project. The students have themselves planned the roles of Indians and the British based on the literature they have read about the colonial relationship between Great Britain and India. When planning their roles, the students were supposed to consider the status or profession and character of the role characters they wanted to play. The students seemed very enthusiastic and eager to act out the motives of their role character in small groups and in the FLE -environment.

In the first sub-study working with a close peer was an essential condition for high-level collaboration. In the history project the students could choose with whom they preferred to work. But when the project started, it was seen that because the students were committed to act according to the roles they had chosen, they wanted to be in contact with the role characters relevant to their own roles. Therefore, the counterpart’s person was no longer as relevant. For example when using personal messages in the FLE environment the leader of the mass movement, a poor Indian farmer, wanted to be in contact with all of those Indians who opposed the British rule. So, she attempted to recruit these people to the mass movement to plan acts against the British, even though some of these students were also from the other school. It seems also that networked interaction enabling anonymity makes it easier for the students to be in contact with all kinds of fellow students.
In the first sub-study it was found out that one reason for minimal critical knowledge building was that the fact-seeking questions set by the teacher promoted memorizing rather than joint critical reasoning. Also it may be that because students do not have very much experience of academic discourse or skills needed in this strategy, they resorted to the strategy most familiar to

them, that is, to an everyday discourse strategy i.e. uncritical joint knowledge sharing. An everyday discourse strategy is inappropriate strategy for discussing scientific phenomena, however (Linn & Burbules 1993). The rules of everyday discourse helps individuals make inferences about what other people mean, relying on the expectation that it 'makes sense', and thus avoid conflicts and disagreements. In contrast, academic discourse regularly results in controversy.

In the second sub-study academic discourse or critical reasoning is supported in the knowledge-building module of the FLE. The knowledge-building module is constructed for supporting higher-level knowledge processing and shared critical reasoning, as well as for directing the students to present their own thoughts and conceptions. Also the learning tasks are designed to support joint critical reasoning, being real problem solving tasks in nature. They are planned so that the students need to take into consideration the role they are playing when discussing the matters. So, the fact that students have to assume different points of view is hoped to create real negotiation situations. The learning tasks are also authentic tasks. For example, a British bishop wanted to learn more about Hinduism. So he wrote a letter via the FLE message system to an Indian Hindu priest to find out more about this religion. The Hindu priest gave an answer and asked the bishop to tell about his own religion by comparing these different religions. In another example, a British officer wrote a newspaper article into the FLE where he justified and argued for the colonial power of Great Britain. This article will surely raise many opinions and responses.

In the first sub-study asymmetry in knowledge sometimes hindered joint working and problem solving. In the second sub-study the fact that the learning tasks are related to different roles, and thus naturally to different points of views within the lessons, is likely to even out the influence of asymmetry in knowledge level. So the learning tasks by themselves will not activate knowledge differences between participants and consequential general status differences in the learning situation as was the case in the first sub-study, where the learning task stressed factual knowledge.

One problem discovered in the first sub-study was that the whole project was spread over a too long period. As a result, at the report writing phase the students had no clear concept of the phenomena they had studied two months earlier in the laboratories. In the history project in the FLE all documents and communication evidence will be stored in the system. For example, in the knowledge-building module all discussion messages can be seen from the beginning of the project. The thinking process of the students will thus be visible throughout the project and students can go back on discussing different topics whenever they want. This will also make it easier for the teacher to monitor students' learning.

So far the students have rehearsed the use of the FLE environment by using personal messages and knowledge building modules. They have written messages individually or in teams to other students. Sending messages or letters has been based on assignments teachers have given each student or also on students' own motives from their role point of view. The nature of the messages has been such that they request a reply. The knowledge building module has so far been used as a shared discussion forum. The teacher has put there different topics to be discussed from the role characters' perspective. One question is for example: "What do you expect from the future of India and Great Britain?" Results of this second sub-study will be available at the beginning of the year 2000.

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4. Normative Influence and Emotionality in Computer-Mediated Groups

Khaled Sakhel

Introduction

An important feature of Computer-mediated Communication (CMC), compared to other modes of communication, is anonymity of its users. Some researchers studying CMC believe that this anonymity accounts for an impersonal interaction with others, and therefore responsible for a diminishing in social influence during CMC (e.g., Kiesler, Siegel, & McGuire, 1984). Anonymity is generally seen as a condition in which participant can express any kind of anti-normative behaviour. During CMC, the participants are anonymous and therefore not only act anti-normative, but also mainly task oriented (Kiesler, Siegel, & McGuire, 1984).

Some other experiments showed that anonymity could also lead to an increase of social influence within a group (Postmes, 1997; Spears, Lea, & Lee, 1990). Spears, Lea & Lee (1990) demonstrated this phenomenon in a study, which manipulated salience of the common group membership and co-presence of group members. Social influence (operationalized as attitude change in the normatively favourable direction) was greatest in groups whose members were isolated.

The Social Identity Model of DEÔndividuation (Spears & Lea, 1992) predicts that anonymity may also lead to an increase in social influence. The here reported experiment studies the strength of social influence and the development of socio-emotional interaction, during CMC. During this study anonymity may increase normative influence in the group discussion via CMC. This is achieved by manipulating both anonymity and the group norm. Anonymity is manipulated by individually identifying participants to each other during interaction, or not. Manipulating group norms is achieved indirectly. Furthermore, because of the interpersonal form of interaction, emotionality (the term used to indicate the expression of emotion) is highly reduced therefore CMC users are expected to perform communication styles, which are mainly task oriented.

The implications of anonymity, the expression of emotion, and possibility of an anonymous and identifiable discussion and problem-solving environment are discussed.

The popularity of the Internet and its commercial part the World Wide Web have accounted for numerous research studying the social psychological aspects of computer-mediated communication (CMC) (Kiesler, Siegel, & McGuire, 1984). An important feature of CMC, compared to other modes of communication, is anonymity of its users. Some researchers studying CMC believe that this anonymity accounts for an impersonal interaction with others, and therefore responsible for a diminishing in social influence during CMC (e.g. Kiesler, Siegel, & McGuire, 1984). Furthermore, because of the interpersonal form of interaction, emotionality (the term used to indicate the expression of emotion) is highly reduced, therefore CMC users are expected to perform communication styles, which are mainly task oriented.

Some other experiments showed that anonymity could also lead to an increase of social influence within a group (Postmes, 1997; Spears, Lea, & Lee, 1990). Spears, Lea & Lee (1990) demonstrated this phenomenon in a study which manipulated salience of the common group membership and co-presence of group members. Social influence (operationalized as attitude change in the normatively favourable direction) was greatest in groups whose members were isolated. However, attitude change only occurred for isolated group members if the common group identity was made salient, not if identity was not salient. Thus no normative influence could be found in co-present groups. A meta-analyses of deindividuation research conforms the finding that deindividuation not necessarily leads to anti-normative behavior, but to the contrary that deindividuation leads to adherence to the groupnorm (Postmes, 1998).

An explanation for these findings is provided by the Social Identity model of DEindividuation (SIDE-model; Spears & Lea, 1992). The SIDE model derives from Social Identity theory and it's practical implications on mass behavior (Reicher, 1984). The Social Identity theory notices that the self encompasses a scope of possible social identities, ranging from individual identity to group identity (Tajfel & Turner, 1986). A social identity is made salient partly in a social context, and can educe from memberships of a group. For example one's identity as 'researcher' may be salient in academic situations whereas the equally accessible categorisation 'football fan' is irrelevant or undesirable and hence not salient. Reicher (1994), after numerous crowd behaviour observations, states that anonymous group members do not necessarily behave in an uninhibited fashion whereby guidelines for action are irrelevant. Anonymity can strengthen group behaviour when the perceived social identity of the group is strong. It is the appropriate social identity, which allows anonymous group members to fully express behaviour according to the norms and rules of the social group they belong to. Thus the SIDE model proposes that when a social identity becomes salient, and the person identifies with the group, conformity to an internalised group norm will be strong (Turner, 1991).

An explanation for this finding is the impossibility for anonymous users to individualise, because there only identification is a number or character displayed on a computerscreen. Therefore group-members tune their attention towards collective and contextual features of the group. Thus anonymity enhances the collective aspects of the group, which in turn guides attitudes and behavior as long as there is identification with the social group.

These post-hoc results in combination with earlier experimental findings makes it necessary to experimentally manipulate a group norm in order to test the influence of anonymity on social influence. The second aim of the study is to explore the possibilities to exchange an socio-emotional form of communication through a text-based only computer system.

The aim of the present study is therefore twofold, first a group norm is manipulated, CMC users communicate either using a task- or an emotional-oriented groupnorm to also study the possibility of a socio-emotional interaction. Secondly the context in which the groups discuss is manipulated; CMC users are either anonymous or identifiable for each other.

Norm manipulation is normally done by providing the participants information about other group members or by a confederate. Both manipulations are very suggestive and therefore their ecological validity is often challenged. The manipulation of a groupnorm during this experiment is done by priming subjects to activate subsequent behavior, without the subjects being aware of this activation or it's consequences on their behavior (Bargh & Barndollar, 1995).

Seemingly unrelated tasks, as correcting unjust formulated sentences influence judgement tasks (e.g. Srull & Wyer, 1979), and actual behaviour (e.g. Dijksterhuis & van Knippenberg, 1996). In small groups such manipulations were not used before, therefore we expect that during discussion the individual members will us the manipulated groupnorm as a guide for interaction, and consequently establish a groupnorm for interaction (cf. Sherif, 1935). On the basis of the above-explained SIDE model it is expected that the established groupnorm will be stronger in the anonymous groups compared to the identifiable groups. By correcting some unjust formulated sentences, subsequent tasks and socio-emotional behavior will be influenced (e.g. Srull & Wyer, 1979; Dijksterhuis & van Knippenberg, 1996). Anonymity is manipulated by individually identifying participants to each other during interaction (by means of pictures displayed on the computer screens), the identifiable condition, or assigning numbers to group members without displaying group members pictures, the anonymous condition.

Method

Participants. Seventy-five undergraduates, 41 female and 34 male, participated for course credits. Subjects were randomly divided into 21 groups of three (nine groups) or four (12 groups) persons. One person did not fill in the questionnaires seriously, and was dropped from the analysis of the questionnaire data.

System

The experiment was conducted on Macintosh computers. Participants communicated through a synchronous computer conference application. Such an application gives the opportunity to type in text and send it by pressing the enter button. All entered texts were displayed on a screen, which was the same for all members of the group, therefore all group-members could read all entered messages from their group at the same time.

Procedure

Upon entering the laboratory participants in the identifiable condition had a digitised picture taken. All participants were then directed to an isolated cubicle with the instruction to start with an unrelated task, (the scrambled sentence task) which will take about 10 minutes. After that they proceed to a judgement task on the computer, which was designed to enhance group cohesiveness (Doosje, Ellemers, & Spears, 1995).

Participants then proceeded to the group discussion task, to discuss possible solutions to an ambiguous dilemma in their group for 15 minutes via a computer conferencing system.

The dilemma was about problems in a hospital and the possible socio-emotional or task-oriented solutions. At the end of the discussion subjects were asked to fill out a questionnaire. The questionnaire consisted of seven point scales anchored with 'not at all' and 'very much' as scale ends.

Dependent variables

The dependent variable checking for anonymity consisted of three questions (alpha = .63), for example "The people I interacted with were personally identifiable to me." Social identification was measured with four questions (alpha = .85), for example "At this moment I identify with group A/Bî. An additional checks was made of participants Private Self-Awareness using an adaptation of the two questions as suggested by Matheson and Zanna (1990), e.g. "I was aware of the way my mind worked" (alpha = .73).

An open question asked the subjects to state their own opinion about what would be the best solution for the problem discussed. These open questions were coded by two independent raters on a five-point scale for the degree of task-orientedness or socio-emotionality. Inter-raters reliability was acceptable (Cohen's kappa = .70).

The content of the discussion was electronically coded using a computer program counting various task- and emotional oriented words in the text. In addition the content was coded using Bales' IPA coding scheme (Bales, 1950). The analyses will focus on the two supra-ordinate categories in the IPA coding scheme: the socio-emotional and the task category. Again inter-raters reliability was high (Cohen's kappa = .73). Suggestions for solutions to the problem were rated for their degree of task-orientedness on a five-point scale. Again inter-raters reliability for 15 percent of interaction was high (kappa = .79).

Regression coefficients (beta weights) of the category codes on the statement number were used to analyse the development of content over time. For example a positive coefficient for positive socio-emotional responses in the IPA scheme would indicate that more of these responses were communicated towards the end of the interactions.

Results

All analyses were conducted at the group level. Groups in the anonymous conditions indicated that their group was more anonymous to them ($M = 3.68$, lower scores indicate more anonymity) compared to identifiable groups ($M = 4.74$, $F(1, 17) = 9.09$, $p < .01$).

Identification did not show the predicted main effect of anonymity $F(1, 17) = .90$, ns, and $F(1, 17) = 1.29$, ns. As expected, anonymity did not affect private self-awareness ($F(1, 17) = 0.13$, ns).

The interaction of individual solutions to the dilemma proposed in the questionnaire was found, $F(1, 17) = 11.93$, $p < .01$, $MSE = 0.42$. Compared to identifiable groups, the anonymous socio-emotionally activated groups suggested more socio-emotional solutions ($M = 3.49$) and anonymous task-oriented primed groups favoured more task-oriented solutions ($M = 2.30$) for the problem, and simple main effects indicated this to be a significant difference, $F(1, 17) = 9.59$, $p < .01$. In the individual solutions for the presented dilemma (open question on the questionnaire) there were no significant main effects. The expected interaction anonymity and priming however was highly significant, ($F(1,17) = 11.93$, $p < .01$).

TABLE 1 Mean score (Standard Deviation) on some dependent variables.

	Anonymous		Identifiable	
	Socio-emotionial n = 6	Task-oriented n = 5	Socio-emotionial n = 5	Task-oriented n = 5
Individual solutions*	3.49^{a} (0.28)	2.30^{b} (0.87)	2.25^{b} (0.71)	3.02^{ab} (0.65)
Number of empathic words	3.20^{a} (1.65)	2.33^{ab} (1.33)	1.37^{b} (1.12)	3.15^{ab} (1.23)
Number of task-oriented words	3.23^{ab} (1.69)	5.16^{ab} (2.80)	5.97^{a} (1.98)	3.12^{b} (0.92)
Development of solutions in time*	$.13^{a}$ (0.25)	$-.11^{b}$ (0.42)	$-.22^{b}$ (0.36)	$.14^{a}$ (0.13)

* Higher scores indicate more empathic solutions, individually or in time.
Means in row with different superscript differ significally, $p < .05$.

As can be seen in Table 1., the socio-emotional anonymous groups used more emphatic solutions and task oriented anonymous groups more task oriented solutions for the presented dilemma, $F(1,17) = 9.59$, $p < .01$. In the identifiable condition the socio-emotional groups used more task oriented solutions compared to the task oriented groups, however this difference was not significant, $F(1, 17) = 3.08$, $p < .10$.

As can be seen in Figure 1., the predicted differences were also found in the number of socio-emotional and task-oriented words used during discussion.

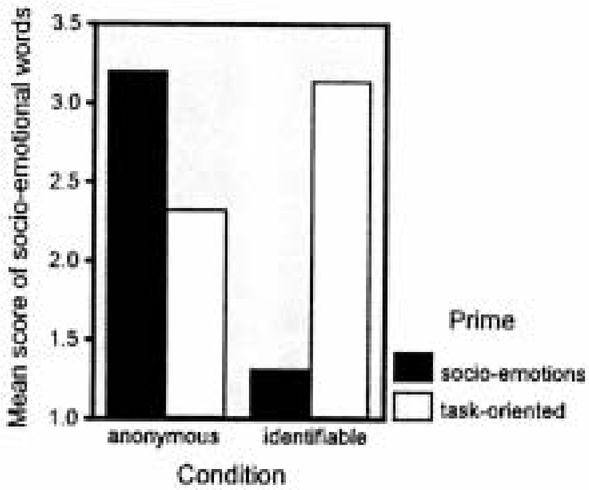

FIGURE 1. Mean number of socio-emotional words used during discussion by condition (anonymous and identifiable) and prime (socio-emotional and task oriented).

Interestingly, the regression coefficients did show a significant interaction in the predicted direction, F (1, 17) = 5.06, p < .04, MSE = 0.09. Across time, the anonymous socio-emotional groups suggested more socio-emotional solutions (M = .13, higher scores indicating more socio-emotional solutions over time) compared to the identifiable socio-emotional groups (M = -.22, simple main effect F(1, 17) = 3.48, p < .08). The anonymous task-oriented groups however proposed solutions that became increasingly task-oriented (M = -.11), while the identifiable task-oriented groups became more socio-emotional in their solutions, although the difference failed to reach significance (M = .14, F(1, 17) = 1.71, p = .20).

Discussion

The reported experiment set out to demonstrate that anonymity in a group could lead to enhanced normative behavior. Results show that anonymous groups choose solutions to a dilemma that are consistent with the prime, whereas identifiable groups do not. This effect occurs both in the solutions to the problem and in the language used during discussion. Moreover, suggested solutions show a predicted development over time, such that anonymous groups tend to behave more prime-consistent over the process of discussion, whereas identifiable groups behave prime-inconsistent over time. This development of primed behavior in the course of interaction is reinforced in anonymous groups, whereas it is restrained in the groups where individuals are identifiable. Furthermore no evidence was found that identifiability increases self-awareness.

The study is suggestive that more social influence can be found in the anonymous group, but it is not conclusive. A possible alternative explanation for the findings based on individual cognitive principles would be that being confronted with one's own picture causes not the customary assimilation of prime and behaviour. The contrast of the 'real' self (made salient through showing the picture to identifiable participants only) with the unconsciously imposed direction of action, would do so.

As mentioned above decreased self-awareness is the mechanism responsible for decreasing attention to social norms and standards. Rather in contrast to predictions derived from this view, anonymous groups evidenced more social influence. However it is important to note that the type of normative influence documented in this study does not correspond to the type of social norms implicated in deindividuation theory. As outlined by Diener (1980) deindividuation theory postulates transgression of general societal norms as a result of anonymity. These studies examined local group norms that do not necessarily correspond to those broader societal norms. This implies deindividuation theory might benefit from distinguishing these two levels of normative influence, and making more apparent when each applies.

The experiment succeeded in demonstrating that CMC is not necessarily more task-oriented. Rather it was demonstrated that socio-emotional interaction styles are very much possible via CMC. Social influence is grounded in the relation of group members to the group as a whole: more attachment to this entity results in more influence, which not only has to be task oriented. Social influence during CMC can very well find it's way through an socio-emotional interaction style.

More generally, with regard to theories of CMC, the view that less social cues imply less social influence is undermined by the findings. On the level of the group a decrease of social cues does not automatically lead to decreased attachment to the social or decreased influence of it: the reverse can occur as well. Parallel to this argument, one can seriously doubt the assumption prevalent in much research that in the interpersonal domain anonymous CMC would in any way be less 'personal' or less personally engaging than more co-present forms of interaction. One important implication of the present research is the way people deal with anonymity during CMC. Anonymity does not automatically create an environment in which behaviour is either uninhibited or task-oriented. During an anonymous CMC group interaction social influence can be strong and participants are able to express socio-emotional communication style, which guide behaviour even after the computer-mediated discussion has finished. More insight in group behaviour during CMC will provide insight of the effects of anonymity and identifiability on communication style and behaviour expressed during interaction and afterwards. The numerous discussion groups on the Internet, and development of web sites creating a group environment by stimulating interactivity among itís users, give an indication of the importance and implications of such research.

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5. On-line Problem-Based Learning in Social Economy

Ulric Björck

Introduction

The recent, rapid and continuing development within the field of Information Technology has lead to new possibilities for the use of Problem-Based Learning (PBL) in Computer Mediated Communication (CMC) (Nuldén & Scheepers, 1998). The focus of this paper, and its contribution to the progress and use of conferencing in CMC, as defined by Santoro (1995), is a study of the use of PBL in on-line courses.

Research on the development and use of communication conventions in CMC has been going on for quite some years now (Murphy, 1997), but still we have a lot to learn (Fetterman, 1998). Apparently, research about the use of PBL in on-line courses is an area that needs further investigations. In this paper the major results reported have been collected from the practical framework used in what I refer to as on-line Problem-Based Learning.

Theoretical framework

This paper takes its theoretical perspective from the area known as sociocultural theory. This is an expansive area of research, and within the rich variety of viewpoints contributed and elaborated, I have come to especially value the ones focusing on the role of mediation in learning. A crucial aspect, highlighting the mediated aspect of learning, is the construction of narrative – essential for learning and for learning to learn (Bruner, 1990; Nelson, 1996). In Nelson’s extensive work she emphasizes the role of language in memory, processing narratives, forming concepts, and understanding others' intentions. Nelson frequently uses Donald's (1991) theories, shortly described in the next paragraph, as a foundation for supporting some of her claims about learning being mainly mediated by language.

Describing the development of the modern mind through three different evolutionary stages of culture and cognition, Donald (1991) presents an explanation of how our mind has changed and developed due to evolutionary aspects. These changes and developments not only influence how we experience and talk about cognition and mind today, they also continue to change cognition as new decades and centuries go by.

In order to scientifically study how we learn, or do not learn, a popular level of analysis is *actio*n. The American Pragmatists, with Mead (1934) and Dewey (1916) as central figures, were some of the first to recognize this as a fundamental aspect. Today, Wertsch (1991) has been using *mediating action* in order to focus that human action employs mediational means, such as tools and language, and that these shape action in essential ways. Wertsch (1998) has also discussed the appropriation as well as mastery of cultural tools, which is important in the further discussion.

In this investigation the student is in the center of action – at the keyboard – or more precisely in the creation of products, artifacts, made by using several cultural tools employed. In many cases, transcripts of asynchronous conferencing in instructional environments have been studied (Harasim, 1990; Henri, 1992). Analyzing transcripts has been established as a favorable way to study communication and cognition in coordination with the ideas in the scientific field of situated cognition. The theories brought forward by the second cognitive revolution put emphasis on learning and knowledge as situated (Bruner, 1990; Harré & Gillett, 1994). When we focus on the actual conversations carried out by the students, we study learning processes that have utilized cultural tools, which leave traces for us to study.

Theoretical background to Problem-Based Learning

Mandl and Reinmann-Rothmeier (1995) suggest that four moderately constructivist principles for developing learning environments may be formulated. According to these, learning should have authentic problems and situations as a starting point, refer to multiple contexts, include multiple perspectives of the learning object, and be embedded in a social context. The writers claim that PBL has a lot of similarity with the constructivist principles and several others accompany them in this view (Ronteltap & Eurelings, 1997; Savery & Duffy, 1995). Another description of PBL presents the method as an instructional strategy emphasizing problem solving in *situated context*, and thus an example of situated learning (Williams, 1998).

PBL, at its most fundamental level, is an instructional method characterized by the use of real world problems as a context for learning critical thinking and problem solving (Duch, 1995). Acquiring skills and knowledge about the essential concepts of what is being studied is also important in PBL. By confronting learners with an ill-structured problem that mirrors real-world problems, the learners will simultaneously develop both problem-solving strategies and disciplinary bases of knowledge as well as the necessary skills needed (Ahlner, Kjellgren, Dahlgren, & Haglund, 1993; Finkle & Torp, 1995). Using PBL, learners might acquire life-long learning skills, including the ability to find and use appropriate learning resources in a number of situations.

PBL is used to engage students in learning, which is based on several theories within cognitive theory. Two prominent ones say that students work on problems perceived as meaningful or relevant, and that people try to fill in the gaps when presented with a situation they do not readily understand. Teachers present students with a problem set, then groups of students analyze the problem, research, discuss, analyze again, and produce tentative explanations, solutions, or recommendations. Some evidence suggests that PBL curricula may enhance both transfer of concepts to new problems and integration of basic science concepts into everyday problems. PBL enhances intrinsic interest in the subject matter and also appears to enhance self-directed learning skills and metacognition. This enhancement may be maintained (Norman & Schmidt, 1992).

Findings from the use of PBL are mostly optimistic and suggest that PBL is suitable for higher education (Jost & et al., 1997). Investigations from other educational environments suggest that the use of PBL might actually increase students' problem-solving capabilities (Gallagher & et al., 1992). However, another exploration suggests that the use of PBL in professional education is ontologically narrow and epistemologically inconsistent with the lived nature of professional practice (Fenwick & Parsons, 1997).

All in all, the theoretical foundations of PBL are not totally clear. Most sources place PBL as developed out of constructivism, while others give emphasis to PBL as an example of situated learning. For the point of this paper it is important to notice that PBL is often referred to as a method, not as a theory, and that the theoretical foundations of PBL, to some extent are inconclusive, but with research investigations in favor of the method. At the same time, it should be noted that some researchers talk about PBL rather as a way of learning (Engel, 1997). PBL is also continuously evolving, making it possible for more course designers to deliver courses that equip students well for the world of practice (Boud & Feletti, 1997). In this light, I will continue with exploring and elaborating how PBL can be used in on-line courses in order to help students learn more effectively.

The use of PBL in on-line courses

A few researchers have reported findings from the use of PBL in on-line courses (Fåhraeus & Männiköö, 1997; LeBlanc, 1997). Compared to research about PBL in face-to-face courses, or research about ordinary classroom education, research is limited when it comes to incorporate PBL in software (Williams, Hemstreet, Liu, & Smith, 1998) or in on-line courses. However, some research has focused on the design of electronic learning environments to support PBL (Ronteltap & Eurelings, 1997). An important guideline from this investigation is that in the learning process, communication appears to be of equal importance as working with information.

Several researchers have reported the use of PBL in delivering coursework on the World Wide Web (Wegner, Holloway, & Crader, 1997) or in Computer Supported Problem-Based Learning (Koschmann, Kelson, Feltovich, & Barrows, 1996). Compared to what is reported in this paper, the use of computer supported PBL in these cases is more focused on how the software can support the PBL process. Nearly all of the findings reported in the use of PBL in CMC stem from investigations in medical education (Boger-Mehall & DeMartino, 1998; Elsner, 1998; Koschmann, 1995; Koschmann, 1994).

Methods and data sources

The results reported in this paper are built on data collected between October 1996 and May 1998 as part of a formative evaluation of a European Union project aiming at stimulating the development of social economy within the European Community.

Formative evaluations (Björck, 1999; Kinzie, 1991; Scriven, 1967; Tessmer, 1994) provide a powerful way of testing assumptions about the suitability of software or computer-based resources by having users of those systems evaluate them as the systems are being used and developed.

The empirical data has been collected using web questionnaires, interviews with students, telephone interviews with dropouts, and by analyzing parts of the conversation carried out within the electronic conference. Two one-year University courses on the Web, with 25 students each, have been studied. Out of the 50 students, more than 30 have been interviewed during a period of one year. The major data material used in this paper consists of the framework used in the course and of students' answers to interview questions about the use of PBL in the on-line courses. In addition, an overview of the messages posted in the conferencing system has been used to determine the different ways of using synchronous and asynchronous conferencing in the groups.

The courses, CLEA 1 (Oct, 1996 – Sept 1997) and CLEA 2 (March 1997 – March 1998), have been offered as distance education, with participants from all over Sweden. The students have been divided into groups of five to seven participants, with a total number of five groups. In the beginning of each course five groups were started. During the course some group members quit their studies, due to various reasons, such as too much to do at their workplace or because of personal reasons. At some stages the groups were changed because of too many dropouts or a change of the group facilitator. At the end of the courses there were three groups in CLEA 1 and four groups in CLEA 2. In the CLEA 1 course 8679 messages were submitted and in the CLEA 2 course 11257 messages were submitted.

From the theoretical part of this paper, I find that attention should be paid to the idea of mediation. Engeström, Miettinen, & Punamäki (1999) suggest that Vygotsky (1978) referred to what we call the mediating artifact as "auxiliary stimulus". These auxiliary stimuli permit us to control our behavior from the outside, which in studies of learning makes it important for us to study the role of artifacts in cognition. In the analysis of the activity in the conferences used in the on-line courses it is crucial to recognize the artefacts involved as important for how the students come to learn, or worse, do not learn. In trying to mention artifacts used by the students and supervisors I am bound to leave out several. However, I find it important to mention the conferencing system used, called

WEST 1. WEST is an asynchronous conferencing system with special messaging possibilities. The Coursework Page is shown in figure 1.

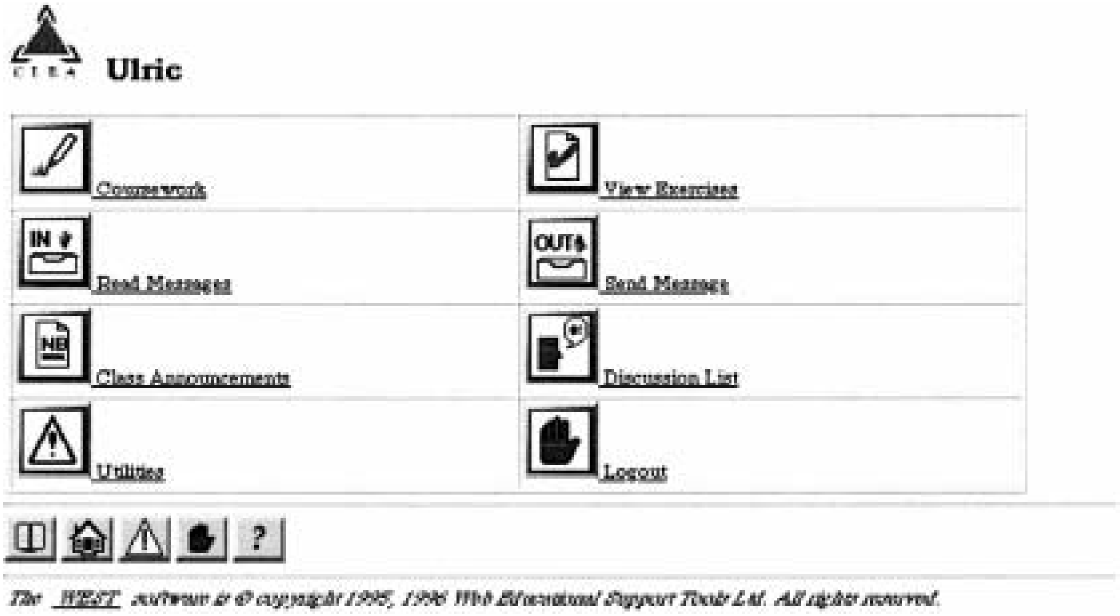

Figure 1: The Coursework Page used by the students in the courses.

In the courses the major function used has been something called the discussion list. In the list students have been able to communicate with each other by posting messages to each other. Each group has used its own discussion list, and for each new case used in the PBL process the group has been given a new list. An example of a discussion list is shown in figure 2. Nowadays the WEST software name is TopClass.

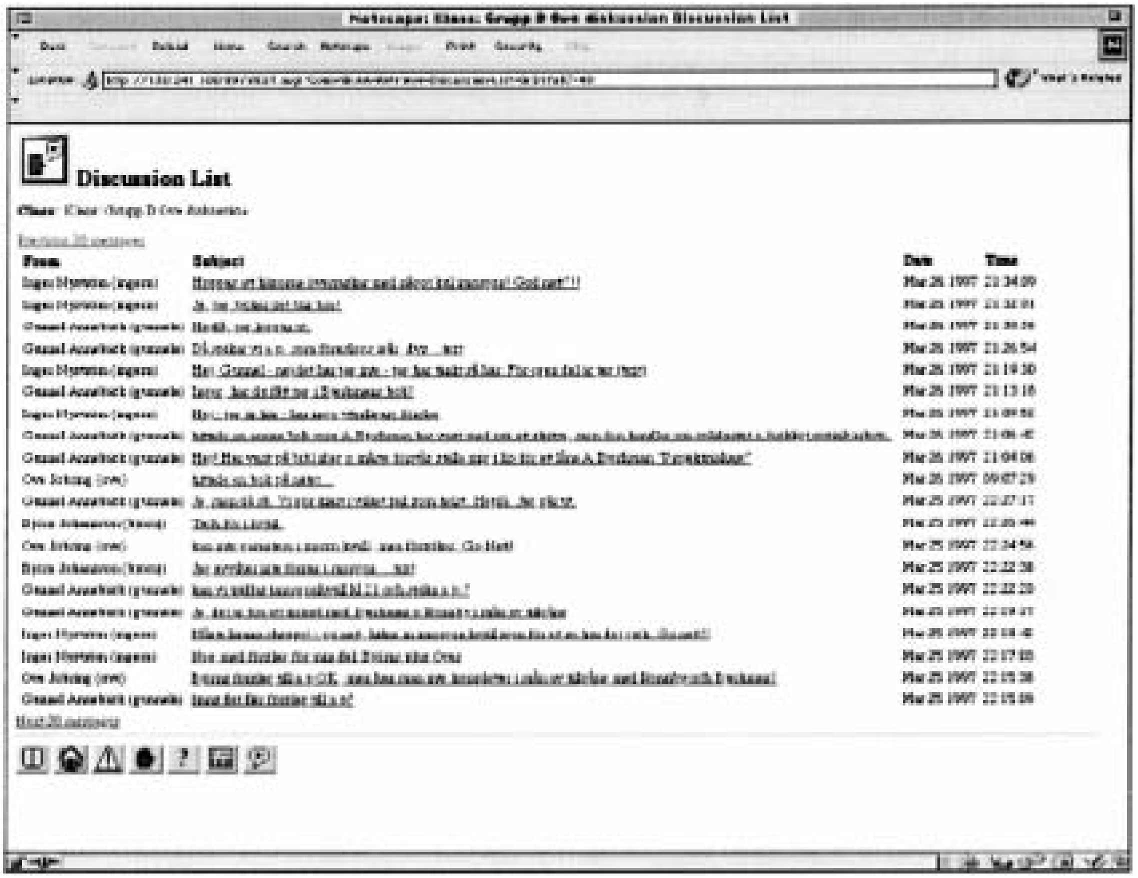

Figure 2: An example of a discussion list used by one of the groups.

Results

The results reported here form part of a greater examination of a rather large empirical data material. In this paper the results focus on the practical framework used in what I refer to as on-line PBL. The main data reported here are the interviews with the students as well as the documents and instructions produced by the course management. In addition to these data, the number of messages submitted in different groups has been used to compare interview answers with what actually happened in the course conferences.

A practical framework

Below you find a simplified model of the steps used in on-line PBL. The course management in the course studied has constructed the model. Reporting the model is an important result for the sake of introducing PBL in on-line courses.

Step 1. *Associations* – Students are presented with a problem on a page called the Coursework Page. Examples of problems could be a case, a research paper, or a newspaper article. Students, working in on-line groups of three to six students, make associations, organize their ideas and previous knowledge related to the problem, and attempt to define the broad nature of the problem by writing messages on a discussion list in the conferencing system.

Step 2. *Learning Issues* – Through discussion, students pose questions on aspects of the problem that they do not understand. These questions, called learning issues, are recorded by the group. Students are continually encouraged to define what they know and even more important what they don't know. Students rank the learning issues generated in the session in order of importance. All students should contribute with at least one learning issue to the discussion list. Students may use the instructor or facilitator to discuss what resources will be needed in order to research the learning issues and where they could be found.

Step 3. *Problem statement* – The next step is to develop a problem statement. A problem statement should come from the students' analysis of what they know. Presented with a problem, students will need to find information to fill in missing gaps. The problem statement may have to be refined as new information is discovered. All students should contribute with at least one problem statement to the discussion list. When the group has decided on a problem statement, the facilitator is notified.

Step 4. *Work Plan* – Students list possible actions, recommendations, solutions, or hypotheses. Asking the questions: "What should we do?" or "What do we need to know?", students list actions to be taken and formulate and test tentative hypotheses. The actions listed will guide searches that may take place on-line, in the library, and in other searches. The students decide on a work plan and notify the facilitator. (The students should complete steps 1 through 4 within one week.)

Step 5. *Studies and work* – When students reconvene, they explore the previous learning issues, integrating their new knowledge into the context of the problem. Students are also encouraged to summarize their knowledge and connect new concepts to old ones. They continue to define new learning issues as they progress through the problem. Students will soon see that learning is an ongoing process, and that there will always be, even for the teacher, learning issues to be explored. The students are not allowed to share, or split, the workload, and all students must read the same literature and use the same problem statement.

Step 6. *Report* – The sixth step is to present and support the solution. As part of closure, teachers require students to communicate their findings and recommendations in a written report. The product should include the problem statement, questions, data gathered, analysis of data, and support for solutions or recommendations based on the data analysis.

Step 7. *Comments* – The students should give feedback on each other's reports. The feedback is given using the discussion list, which is open for everyone in the group.

Step 8. *Summary* – In the final step an assigned chairman (one of the students) will make a short summary on basis of the reports and comments, which will be sent to the facilitator.

The steps used in the course are much the same as in the model presented by Barrows (Engel, 1997). A little difference from the model presented by Barrows, in the instructions to the students, is a lack of an explicit instruction to the students to reflect on their own learning during a "time out".

The use of the conferencing system in relation to the use of the steps in on-line PBL

When analyzing the interviews it is rather clear that the groups have used somewhat different approaches in working with on-line PBL. Some groups have used on-line PBL in an asynchronous way where they have not really focused on meeting at specific times on the Internet. Other groups have decided to do so.

The most intense use of the conferencing system is found between step 1–4. Especially step 3, the problem statement; seems to stimulate discussion in the conferencing system. When the problem statement has been discussed, most of the messages have been posted simultaneously in those groups that have used a more synchronous way of working. In using the steps in on-line PBL the students feel that they learn a lot from each other. Some students claim that they engage in discussion with others in a way that most of them have not experienced in previous higher education. The ability for students to get better at expressing themselves also has support in the interview data. “I think that I have become more at ease in the way that I express myself during this year. I feel that it is a little bit easier, a little bit more smoothly. I think that the course has had a good influence on me (female student in CLEA 1).”

However, the positive outcomes of the on-line PBL approach take time to establish for students as well as facilitators. For students to engage in dialogic encounters with each other, a feel of trust and continuity must characterize the on-line social climate. When this is established students might continue to use the conferencing facilities long time after that the actual course has ended. In both of the CLEA courses, students continued after the end of the courses, some groups continued for as long time as six month.

Discussion

The presented steps used in on-line PBL seem to be working practically in a good order. An improvement of the steps used could be to further emphasize the original steps presented by Barrow’s that instructs students to take “time out” in order to reflect on their own learning.

The analysis of PBL in the on-line courses shows that students in different groups choose two rather different ways of working with PBL in the on-line environment. The first and traditional way of working with PBL is synchronous, which in on-line PBL means to meet on the Internet at a certain time and use chat, a synchronous method, to discuss and walk through the steps used in the PBL method. The second and new way to use the principles of PBL is to meet asynchronously and work through the different steps. The first way, the traditional way, makes it important to have good synchronous communication possibilities between the students, such as chat. The groups that have used asynchronous communication are pleased with using ordinary conferencing software and are not missing the use of chat functions.

The positive outcomes of the on-line PBL approach take time to establish for students as well as facilitators, but when this is established the “pay-off” seems to be pretty high. The fact that several students, on their own have continued to use the conferencing system for as long as six months after their last session of on-line PBL suggest that they have appropriated as well as mastered these tools. This corresponds with the findings of Wertsch (1998) in reporting from Herrenkohl’s investigations on the use of reciprocal teaching. In on-line PBL, as well as in the reported studies of reciprocal teaching, students have made the tools their own and spontaneously employed them “without the need of continuing outside support, or scaffolding (p 137)”. Still, the teachers or supervisors in PBL must guide, probe and support students' initiatives, not lecture, direct or provide easy solutions, even though a small number of somewhat traditional students might prefer this. When teachers incorporate PBL in their on-line courses, they empower their students to take a responsible role in their learning – and as a result, faculty must be ready to yield some of their own authority in the virtual classroom to their students. From the theoretical background presented in this paper we find that the changes and developments in cognition not only affect how we experience and talk about our cognition and our mind today, but it also continues to change our cognition as time goes by. The use of PBL in on-line learning is both recognition and adaptation of sociocultural theories about cognition and learning as well as a potential development or change of cognition. When the students use the steps in on-line PBL they all engage in the construction of narrative (Bruner, 1990), which without a doubt lead to learning.

Educational and scientific importance of the study

The study is important for both educational and scientific reasons. Educators are curious about the use of PBL in education and in on-line courses (Fåhraeus & Männikö, 1997), and yet, we don’t really know much about it since we haven’t been using on-line courses for very long. In fact, we have been using on-line courses based on PBL even less, which alone calls for closer investigations such as this and others. Results from the study are used in the continued development of European Union projects, in the Virtual University project, and in courses at Göteborg University, Sweden. The continued study of PBL in on-line learning has also been included in a research program at the

Viktoria Institute, a major IT research foundation, owned by Göteborg University, Chalmers, Volvo Inc., Ericsson Inc., SKF Inc. and Hogia Inc.

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6. Developing Nursing Expertise in Simulation-based Learning Environments

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ABSTRACT

The work of nurse anaesthetists is carried out in a highly technological environment, where patient care is provided in close collaboration with other members of hospital staff. The expertise of these nurses and how this is developed is of vital importance. Furthermore, the use of computerised pedagogical tools to support learning within an educational setting is of special interest. The main aim of this paper is to investigate how the use of one of these tools, a simulation based learning environment, can contribute to learning in the domain of anaesthesia care. The study is carried out within the framework of socio-cultural theory. From this perspective, learning is viewed as being situated in communities of practice, where interaction between individuals, and between artefacts and individuals, is considered as central in the learning process. Here, we will present results from a study of how trainee nurse anaesthetists use computer simulations and discuss issues concerning their learning processes. The planning, implementation and debriefing phases of one training session are scrutinised with respect to the framing of problems and implications for learning. The results support the assumption that work in computer based learning environments can influence assessment procedures and decision making skills in significant ways, and that computer-based learning environments provide productive means for goal directed collaborative learning activities.

Introduction

The characteristics of knowledge inherent in the work of professionals are an issue that is of vital importance. Research on the development of this knowledge may have crucial implications in future professional education. Furthermore, new computer-based technologies change the conditions for the work of professionals and also provide new tools for learning and the development of professional expertise.

This paper is focused on the professional work of nurse anaesthetists, where certain main features can be identified: 1) The care of patients comprises a wide range of tasks, including communicative activities, as well as the maintenance of the patients physiological functions. 2) Patient care relies, to an increasing extent, upon the extensive use of medical-technical equipment, and computer based technologies. 3) This work is carried out in collaboration with others in teams with a clear division of labour. The teams consist of other nurses and physicians with specialised functions.

In the study presented in this paper, we will explore how simulation-based learning environments can contribute to the development of professional expertise in the domain of anaesthesia care. The study is carried out within a socio-cultural framework (Wertsch, 1995; Lave and Wenger, 1991) and the activity under scrutiny could be regarded as an instance of Computer Supported Collaborative Learning, CSCL (Dillenbourg, Baker, Blaye & O’Malley, 1996; Koschmann, 1996).

Lave and Wenger (1991) have formulated a theoretical basis for studies of learning from a socio-cultural perspective. They describe learning as a move from peripheral participation in communities of practice towards an increased level of participation and involvement. Learning is regarded as situated and includes the development of identity. Interaction between individuals is central in the learning process, but interaction with artefacts also contributes to an understanding of what is going on in a certain practice. Lave and Wenger use the term *transparency* which, in connection with technology refers to, “the way in which using artefacts and understanding their significance interact to become one learning process“(p. 102). In this way, artefacts are objects of, as well as tools for learning. A central concept is *structuring resources*, which is defined as the structuring effects of activities in social practices on learning processes that is, how activities in a situation come together, shape each other, and generate qualitative differences within specific ongoing activities. This means that attention must be paid to how experiences from well-known situations are used to frame the situation and the way in which activities are carried out. Thus, how people make use of structuring resources is decisive for an understanding of learning processes (Lave, 1988; Lave & Wenger, 1991). The term *framing*, when used here, refers to how our definition of a situation is built up in accordance with principles of organisation, which govern events and our subjective involvement in them. Thereby aspects of events that otherwise would have been meaningless are transformed to something meaningful (Goffman, 1974).

Dillenbourg et al. (1996) observe that research on computers and learning has shifted its focus from the potential for individualised learning towards collaborative learning. Instead of the individual, the group and the emergent, socially constructed properties of interaction have become the units of analysis. Collaborative learning is described as “a co-ordinated synchronous activity that is the result of a continued attempt to construct and maintain a shared conception of a problem“ (p. 190). In research, *negotiation* – how individuals come to an agreement about the important aspects of a problem through interaction – is often central in the analysis. When collaborative interaction is mediated by computer systems, the design of these systems has an impact on the activity. Researchers interested in CSCL mainly focus on how the introduction of computer tools changes the interaction and the learning processes.

The main aim of this study is to investigate how the use of simulation-based learning environments can contribute to learning in the domain of anaesthesia care. The results are based on data from the introduction of a computer-based simulation in a course in anaesthesia care for nurses. We will focus on how nurses during their training to become nurse anaesthetists use computer simulations and discuss what this will mean for their learning processes.

Computer-simulations in the education of nurses

A computer-simulation can be defined in general as a program that consists of a model of some aspect of the world. It allows the user to make inputs by changing the parameters of the model, run the model and make conclusions about the results displayed. That means that, “a simulation is possible for anything that can be implemented as a model relating two or more parameters, where changes to one parameter produce changes in another“ (Laurillard, 1993, p. 132).

Two main categories of computer-simulations have been used in nursing education. The first category includes simulations where the model responds to manipulations of some physical components, and the results are displayed on a screen or on authentic monitors. In the second category, the underlying model is represented on the screen and the user interacts with the software using the keyboard and mouse. Both of those main categories can be further subdivided with respect to the specificity-generality of the simulated events and the nature of the tasks that can be trained with them. This categorisation is illustrated in figure 1:

	Specific areas	General areas
Simulations with physical components	Q1. Interaction with medical-technical equipment Training for specific tasks and technical skills	Q2. Environmental training (example for work in operation rooms) Training for technical skills and in recognising general patient reactions Training for collaboration and decision-making in teams
Simulations on computer screen	Q3. Training for skills in interpretation of results from different forms of medical examinations (laboratory measurements, electrocardiograms etc) and interpretation of symptoms related to specific diseases	Q4. Training skills in recognising general patient reactions; apprehend what is important in relation to different situations; decision-making and priority giving

Figure 1. Categorisation of different forms of computer-based simulations used in the education of nurses.

Merryl and Baker (1996) describe a simulation that can exemplify the type in the first quadrant (Q1). The purpose of the simulation is to train manual skills in the handling of intravenous needles, which is a common task in the work of nurses. Fletcher (1995) and Bower (1997) describe a simulation of the type in the second quadrant (Q2). The simulation includes an entire operating room with medical-technical equipment. A mannequin represents the patient. The underlying model responds to the user/users' actions by displaying reactions on the monitors and on the mannequin. It is stressed that the simulation affords good opportunities for the realistic training of teams in different critical situations. The interpretation of electrocardiograms (ECG) is an example of the type in the third quadrant (Q3). This type of simulation is presented by Wright (1995), but its use has not been reported in recent years and can be considered as an early form of application. An example of a simulation belonging to the fourth quadrant (Q4) is a soft-ware program developed for the examination of nurses in the US by the National Council Licensure Examination for Registrated Nurses (NCLEX), as described by Krawzac & Bersky (1995) and Erickson Forker & Mc Donald (1996). The simulation consists of a series of case scenarios that simulate nurse-client encounters. Each scenario starts with a brief introduction to the client situation. The examinee then carries out nursing activities that include the gathering of relevant data about the client. The client's status changes over time in response to the user's actions and as the underlying health problem unfolds.

Experiences from the use of computers in nursing education suggest that new technologies improve goal-directed learning. Studies of learning effects have mainly been concerned with test results showing that the students perform better with computer-aided instruction (Bloom & Trice, 1997; De Amicis, 1997). However, although the reported evaluations by trainees have been unanimously positive (Bower, 1997; Fletcher, 1995; O'Donnell, Fletcher, Dixon & Palmer. 1998), there is still a lack of empirical data showing that even the use of advanced simulators supports any improvement in actual job performance. Helmreich (1999) addresses the issue of evaluations of group functioning in simulator training. One of the conclusions that can be drawn from aviation research, according to Helmreich, is that training through simulation is not sufficient to effect significant behavioural change in either flight crews or medical teams. He suggests that more formal didactic training in human performance issues is needed in order to place simulator training in a meaningful context.

In conclusion, the results indicate that there is a potential for developing important aspects of a nurse's work by using computer-simulations. One limitation of the research presented above is that issues about how nursing expertise develops have not been fully addressed. Another is that the collaborative aspects of learning have not been elucidated. In this study we will address both of these issues.

Method

The simulation software

Swedish simulation software in anaesthesiology, Anestesi Simulator 3.0, was introduced in a one-year anaesthesia care course for registered nurses. The simulation included 12 case scenarios of different degrees of difficulty, and provides training in the accomplishment of general anaesthesia. When a case scenario is chosen, the *record* of the simulated patient is displayed, including results of laboratory tests and a short description of the medical history. As the record is closed, different alternatives for pre-medicationare displayed in a dialogue box. When one of the alternatives has been chosen, another dialogue box, for the choice of different medical equipment to be used during the anaesthesia, appears. After those choices have been made the real simulation starts, which implies that a time factor is included. A schematic picture of a patient on an operating table is shown as well as the monitors usually available in an operating room, which also display different readings (Figure 2). The user can now administer drugs and infusions from the menus in the upper margin and, when choices are made, dialogue boxes appear where the doses and rate of infusions can be stated. The anaesthesia machine is monitored by moving the levers on it with the mouse cursor. Decisions about intubation[3] and the start of the surgical operation are also performed from the menus. The condition of the simulated patient is controlled by the monitors displaying ECG[4], heart rate, blood pressure, saturation of oxygen in the blood et cetera. The user also gets access to laboratory data from the menus. By clicking on the symbolised patient, it is possible to see the size of the pupils, the breathing rate and if the simulated patient becomes cyanotic. The grade of consciousness is displayed by text and is divided into five levels. The amount of bleeding and rate of urinary

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3 Insertion of a breathing tube through the mouth or nose into the trachea to maintain the airway free and for the delivery of an anaesthetic gas and oxygen

4 Electrocardiogram, chart of the electric activity of the heart muscle. Allows diagnosis of specific cardiac abnormalities

output can also be checked by a click on the symbolised containers under the depicted operating table.

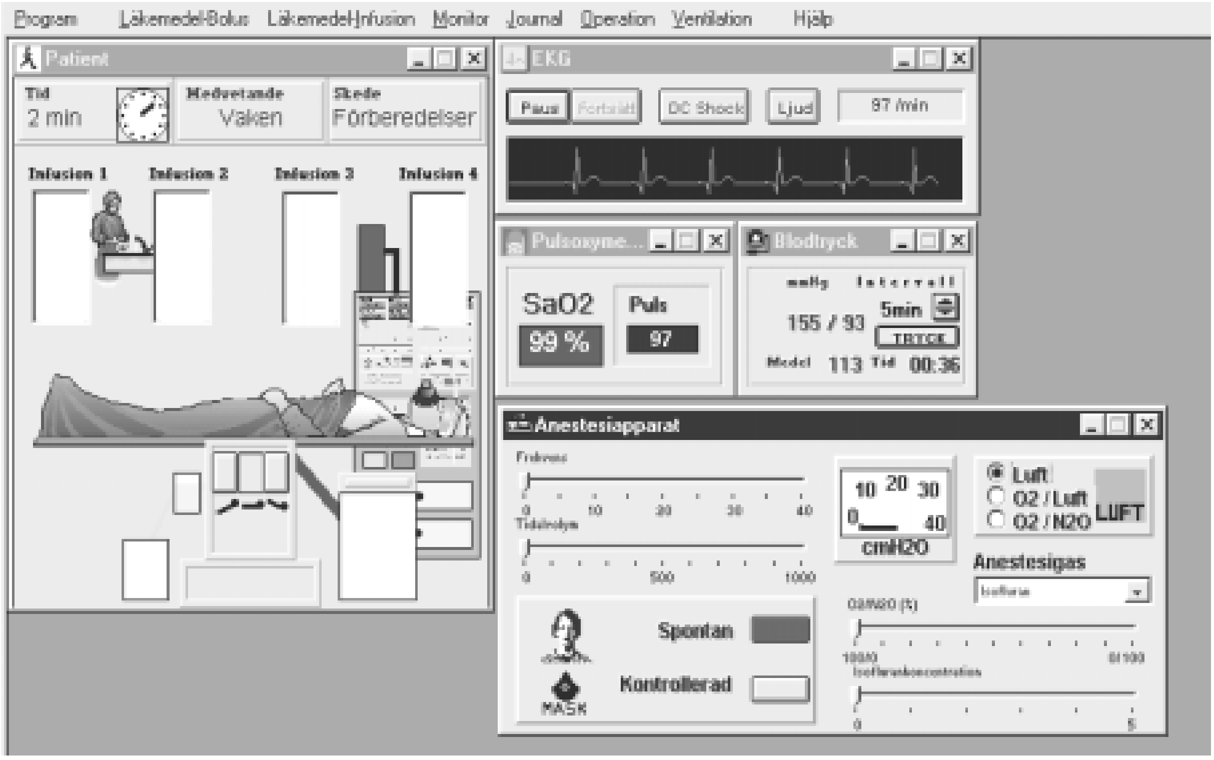

Figure 2. Appearance of the screen from the start of the simulation with the exception of the anaesthesia machine down to the right, which is activated by an icon.

By choosing *advanced monitoring*, the user gets access to readings for central venous pressure and arterial blood pressure (continuous) as well as several other parameters of the imagined patient's physiology. There is also a function showing the remaining effects of the drugs administered (in percent). Furthermore, it is possible to check readings of laboratory tests during the anaesthesia, and also the composition of the expired gases. The time factor in the program represents real-time, as regards how long the operation lasts, the effects of drugs et cetera. There is a function for temporarily stopping the simulation, and the speed of the simulation can be altered. A function for evaluation is available, which is based on the extent to which a sample of parameters has been kept within certain limits during the simulation. Graphs of parameters, like blood pressure and heart rate, are automatically registered in an *anaesthesia record*, as well as most of the interventions undertaken during the simulation. The record can be printed out during the simulation or after the simulation has been finished.

Subjects

The subjects of this study were 7 nurses, 6 women and 1 man, attending a one-year anaesthesia care course. Their average length of their working experience was 7, 3 years, ranging from 3 to 12 years. None of them had experience of work as nurse anaesthetists. Four of them had been working within closely related domains, such as emergency, critical or pre-hospital care.

Procedure

The simulation was introduced as part of the general instruction on anaesthesia care of the beginning of the course. This study was conducted in the second semester, that is, during the trainees' specialisation in anaesthesia care. About half of that semester was practical training at hospitals. After 7 weeks of theoretical studies in the second semester, just before the period of practical training started, a new case scenario was introduced under supervised training. The learning environment was structured as three two-hour lessons and the nurses trained with the simulation in groups of two or three. The participants themselves arranged for the formation of three groups, which were the same in all lessons. The course teacher was present, and the trainees could ask her for advice or explanations whenever they wanted. They were told, however, to create strategies for the anaesthesia by themselves, to try to carry them out and ask for support only if they could not manage. After the simulation was finished, the teacher and the trainees had the opportunity to discuss alternative solutions to the problems that had occurred during the training session and other issues of interest. The course of events during the lesson was divided into three phases: 1) The planning of the anaesthesia for the patient; 2) Implementing the anaesthesia; 3) Debriefing by the teacher.

Data collection

All three groups were videotaped during three of the sessions. The positions of the cameras are described in figure 3. To capture the trainees' interaction, both verbal and gesticulative, three different recordings were undertaken. One camera (1) was situated immediately behind the trainees, directed towards the monitor, and which captured their pointing to different elements on the computer screen (4) as well as the dialogue between the trainees and the teacher. Another camera (2) was positioned at the side, a bit in front of the trainees, for registration of their non-verbal interaction and of their use of literature, notes etc. This camera angle also made it possible to tape most of the teacher-trainee interaction. The picture from the computer screen was taped directly on a video recorder (3), mainly to make it possible to observe details visible in the simulation, even if someone were to move in between the camera and the monitor.

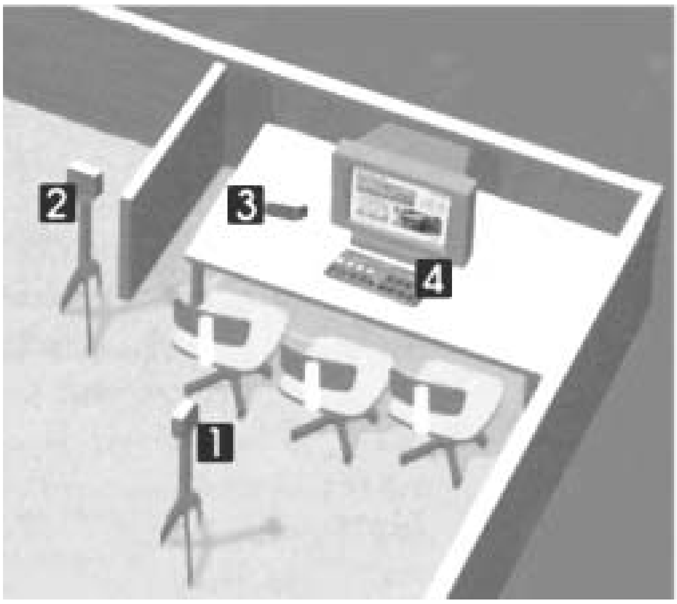

Figure 3. Equipment for the registration of data and camera positions in relation to the trainees and the computer screen.

Data analysis

Data was analysed within the framework of CSCL (Dillenbourg et al., 1996; Koschmann, 1996), founded on the theories of learning of Lave (1988) and Lave and Wenger (1991), with the focus on Lave's concept, structuring resources. Videotapes from the first occasion of training were studied and episodes for analysis were segmented from the tapes. The idea was to find episodes, where the trainees' attempts to come to an agreement of how to manage the unfolding problems were salient. One episode from each of the different phases of the session was then transcribed. The results, presented below, are based on an analysis of the participants' interaction in those episodes and their verbal and non-verbal communication, as well as the role of the artefact in this interaction. Excerpts from the episodes are presented and discussed with the aim of demonstrating the most typical interaction situations. Furthermore, the usefulness of the software for collaborative learning activities is scrutinised as regards the three dimensions: interface, representations, and function (Kolodner & Guzdial, 1996).

Results

The results presented here are based on the analysis of the first training session for a group of three participants. The session was conducted after they had been in hospital practice for one week out of nine in their last practice period.

Collaborative learning and the framing of the activities

As previously described, there are three phases in the lesson: 1) The planning of the anaesthesia for the patient; 2) Implementing the anaesthesia; 3) Debriefing by the teacher. Each phase will be described shortly and examples from them will be presented. Different aspects of the training are salient in the different phases, and the results will be structured accordingly. In the planning and the implementation phases, the focus of analysis is on the use of structuring resources in the participants' framing of the problems. In the debriefing phase, the implications of training with the simulation for collaborative learning activities are highlighted.

The planning phase

A case scenario simulating a man undergoing a laparoscopic cholecystectomy[5] was selected. Before the real simulation started, the trainees are confronted with the *medical record* of the case scenario, which forms the point of departure for the planning of the anaesthesia. This planning includes an inventory of the patient's medical and surgical history, allergies, current medication and the results of laboratory tests. The trainees start with a discussion of what kind of situation they are confronted with. There was obviously a need for framing the

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[5] Surgical removal of the gallbladder performed to treat inflammation in the gallbladder or to remove stones in the bladder and the bile ducts

situation, to decide how to look upon the simulation, which is demonstrated in the following excerpt:

Anna: *Should we assume that he is treated in hospital or that he is an outpatient? John: What did you think about then?*

Anna *I just thought that if he is an inpatient you may have more time for the preoperative talk and maybe check up a little bit more. In this case you may only read the journal and the papers [documents] in that and about previous anaesthesia.*

Teacher: *Even if he is treated in hospital he could be coming from his home in the morning. Anna: We will meet him in the morning then.*

John: *That's the way it usually is anyway. Its not often we visit the patients [on the ward] in advance. Anna: But if we follow what we have learnt in our education we should try to introduce these preoperative interviews.*

From the medical record it was not explicit if the patient was an outpatient or if he was treated in hospital. Why was it necessary for them to know if he was an outpatient then? There are some possible reasons. For example, it is important for the anaesthetic nurse to know if the patient has been eating or drinking anything before the anaesthesia. If he has been treated in hospital, they may get indications that such conditions are under control. However, the main reason for their attempt to frame the situation seems to be a need to establish consensus about how to look upon the simulation, if it should be regarded as a knowledge object in itself, or as if the object is a real patient behind the simulation. To be able to conduct the preoperative actions needed in the simulation there is obviously a need to rely on other experiences, going beyond the simulation itself. In this case, one of the trainees, Anna, refers to a specific task they had been instructed on in their course in order to structure the problem. A question by Anna in the beginning of the lesson, when they were confronted with the case scenario reveals this:

Anna: *Now we will undertake a little preoperative [inaudible] and we go through the whole thing?*
Teacher: *Exactly.*

There is, however, a conflict between the trainees concerning the extent to which they should deal with the situation as a *pretended reality* or as *running a simulation*. The previous discussion reveals such a conflict, and it is yet more salient in the following excerpt:

Anna: He must have a newly recorded ECG.

John: Presuppose that it is assessed.

Maria: It has to be assessed and accepted, so that is…

Although the question is relevant in the actual practice of nurse anaesthetists, the simulation could be run without access to all the information needed in authentic settings, as the comments of John and Maria indicate. There are also different opinions about which of the structuring resources to rely on: those supplied by activities in educational settings, like instruction and reading literature, or those supplied by activities at work. Anna relies on the content from their course, but Maria and John do not find this relevant. John refers to how it usually is in work practice. In both cases, however, their familiarity with activities outside the actual situation helped them to frame the problem, which can be looked upon as an instance of utilising structuring resources (Lave, 1988).

After that, they continue to check if different data is available in the medical record of the case and discuss what consequences different pieces of information may have for the planned anaesthesia. They now conduct the preoperative preparations based on data available in the simulation. They had come to an agreement on how to manage the situation at hand. The agreement, however, does not mean that a full consensus has been established; rather they agree upon important aspects of the problem (Dillenbourg et al., 1996). As the *preoperative interview* was rejected as a relevant form in the simulation situation, and their attention was directed to the data supplied in the simulation, the conflict between education and work practice as structuring resources faded.

The need to frame the situations appears in several events as they talk about where in the operating unit actions are undertaken, for example whether they are in the preparation room or in the operating room. The clarifications about localisation are triggered by questions of what to do on certain occasions, for example if it is possible to administer oxygen or not, but also to give a sequential order to different steps before and during the anaesthesia.

The implementation phase

The implementing phase begins when the participants start the simulated case scenario. They administer the drugs they have planned in the previous phase and start the operation (after 10 minutes). The task includes balancing the administration of drugs and intravenous fluids in relation to their effects on the patient's physiological condition, as displayed by the monitors and laboratory readings represented in the simulation. In the training situation, no explicit statements are made in advance of the goals for a successfully implemented anaesthesia. When they are running the simulation, however, this turns out to be a central problem. Many anaesthetics lead to decreasing blood pressure, but the blood pressure could also decrease for other reasons, for example hypovolemia or heart failure. Furthermore, the heart rate is related to variations in these parameters, but a rapid heart rate can also be caused by pain or the low saturation of oxygen in the blood. Low saturation of oxygen, in turn, could be caused by the insufficient ventilation and exchange of gases in the lungs, as well as by poor blood circulation. The running simulation confronts the trainees with problems that include a complex interplay of all those parameters. In the first event, scrutinised here, the low blood pressure of the patient is identified as a problem. The low blood pressure had been commented upon previously by the trainees, as an effect of the anaesthetic gases and as requiring larger amount of intravenous liquids, and dealt with by reducing the gas flow (Isoflurane[6]). Initially they also increased the speed of the infusions (2 minutes after starting the simulated surgery). Now (about 15 minutes later), the teacher directs their attention again to the low blood pressure (current pressure is 92/55):

Teacher: You had problems with a significantly low blood pressure in the beginning, with a patient that was in very deep narcosis. What could you have done to be in a better position?

Anna: The low blood pressure…

Maria: What you begin with, it is giving half a litre Hess[7] before… filling them up, and then it is that you do not give as much [inaudible]. Maybe a little smaller dose.

Anna: Eeeh… I maybe… or I do not think I would have been giving Hess, rather Ringer[8] instead, and filled up then. Or administered that instead of Hess.

Maria: It works very well. There were no problems with the pressure.

Anna: Maybe it is not the first you choose.

Teacher: No [agrees with Anna]

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6 A type of anaesthetic gas, which side-effect is vaso-dilatation that causes decreasing blood pressure.

7 A plasma volume extender

8 A balanced saline liquid

The event demonstrates how the trainees try to manage the problem of low blood pressure and make sense of the situation by relying on different resources. It seemed to be obvious for these experienced nurses that the blood pressure was too low. One of them also compared it with the initial blood pressure in order to get a point of reference for what to expect in this particular case. The trainees did not discuss further if the pressure was unacceptably low or not. There seemed to be an unspoken agreement about that. Two proposals are made by the trainees to explain why the situation had unfolded in this undesirable way. Maria says that they should have administered Hess in order to *filling up* the patient and Anna suggests another form of infusion. Attempts to increase the blood volume in the case of low blood pressure can be regarded as reasonable as there is a physiological relation between volume and pressure. The other suggestion, to give a smaller dose of anaesthetics, is also reasonable considering that the narcosis was too deep and that the drug in use also causes vasodilatation, which will decrease the blood pressure. In this situation, it is likely that increasing the blood volume can compensate for the vasodilatation and thereby contribute to keeping the pressure on an acceptable level. So, what resources did they rely on in order to make sense of the problem? Maria's suggestion, to give Hess, refers to experiences from events occurring during her practice in hospital, where, as she said, *it works very well*. The explanation given, which Anna adopts, also has a feature of work-talk like filling up. Their line of reasoning could just as well be supported by physiological theories from their education but, as they run the simulation, they frame the situation in terms of events in their work practice and give their reasons using work phrases.

The teacher gives recommendations as to how the undesirable situation could have been avoided. She suggests that it would be better to begin with higher doses of analgesics, wait and see, then give a smaller dose of anaesthetics and start by giving less gas (Isoflurane) than the trainees did. The suggestions include giving the anaesthetic drugs slowly, a function that is not available in the actual program, which is commented upon by Anna. She also stresses that there are better conditions for regulating the consciousness of real patients than for managing that task in the simulation. Until then, the discussion of the simulated episode of low blood pressure has been conducted as if there was a real patient to be taken care of. Now, however, this mode is interrupted by one of the trainees pointing to the discrepancies between the simulation and reality. The event described in the implementation phase demonstrates the dynamic character of the simulation: how many factors interact and how actions undertaken at one point of time influence the subsequent course of events. This contributes to the difficulties confronted by the trainees, and the multiple possibilities to interpret why the simulation unfolds in the way it does. Because of the complexity of the simulation, a full account of how the different parameters interact was impossible to produce, even for an experienced anaesthetist like the teacher.

In summary, the way of managing the situation could have been better, according to the results of the evaluation provided by the software. Several episodes during the session demonstrated the trainees' reliance on quite divergent experiences from work practice. This fact, in combination with their short experience of anaesthesia care, might have contributed to their difficulties in coming to an agreement on a common strategy. A possible way of resolving those conflicting strategies could have been by reference to the theoretical content of their course. Such references, however, were not explicitly made. One exception though, is the reference to *preoperative interviews* mentioned in the planning phase. Conclusions about why theoretical concepts and models were not utilised to a greater extent, as a means for arriving at a common understanding, could not be made from the data provided in a single example. Difficulties, however, in applying concepts and sets of concepts on ill-structured knowledge domains have been attended to by Feltovich, Spiro, Coulson and Feltovich (1996), who describe an ill-structured knowledge domain as characterised by the tendency of many dimensions to interact and of the meaning and interpretation of concepts to depend on the particular situation. Feltovich et al. argue that clinical medicine is an example of such a domain and describe several types of difficulties in learning this. First, they argue, there is an over-reliance on a single basic form of understanding and analogy. Second, the learning of complex material involves the misunderstanding of situations in which there are multiple, co-occurring processes or dimensions of interaction. In those cases, learners often rely on a limited number of the dimensions, rather than the many that are pertinent. The reasoning of the fairly experienced trainees in this study demonstrates a capability to manage a multiplicity of dimensions, but also instances of a restricted perspective.

The debriefing phase

After finishing the simulation, the trainees and their teacher assessed the outcome of the simulated anaesthesia together concluding with a discussion of alternative ways of carrying out the anaesthesia. In this debriefing phase, a discussion starts about what working together with the simulation has been like. The discussion is initiated by John, who says that in running the simulation on his own he is accustomed to administer certain anaesthetics that he feels safe with and knows how they work. In the present situation, he argues, they had to compromise and so it was impossible to find out why things went wrong. The teacher, on the contrary, argues that it is positive from an educational point of view to call into question this feeling of safety. Her argument is that it is too early to come locked up in routine patterns. Maria, however, supports John's view as she says that, in reality at least, there are not three nurse anaesthetists suggesting different things during the same anaesthesia. One of the trainees, however, adopts the teacher's line of argument and the different opinions among the nurses are exemplified in the following excerpt:

Anna: *At the same time I agree with you that this is a good thing [referring to the teachers' argument], that you are not stuck in routine patterns. Those things that happened now…*

John: *Yes, but I think it is hard to grasp [what is happening], because I might not have done it in your way, that is just what's wrong then.*

On the one hand, a need for openness towards other alternatives is important. On the other though, there is a need for feeling safe and testing one's own hypotheses. The conflicting opinions reflect upon and relate to the issue of whether training with the simulation supports collaborative work and learning.

Obviously there was a great deal of discussion among the trainees in order to come to an agreement as to how to manage the different problems. During their discussion and as the simulation unfolded, new problems emerged and old ones were aggravated. The possibility to take time out by making use of the pause function in the simulation was not utilised. Furthermore, the trainees, as was apparent in the low-blood-pressure episode, were not able to manage the problem in a desirable way, reflecting the fact that they did not fully comprehend the behaviour of the system. From that point of view, the trainees were, to a certain extent, able to achieve a shared understanding of the problem. In the actual situation, however, the simulation did not afford sufficient possibilities for the nurses to gain an understanding that that could have served as a foundation for proper actions.

Usefulness of the software

Kolodner and Guzdial (1996) argue that a deep understanding is the explicit goal in the use of CSCL software, and that it is designed to promote a kind of reflection that can lead to successful learning. They emphasise three important facets of the software as being critical for its usefulness: interface, representations, and function.
Interface. The forms of interactions allowed in the actual simulation provide opportunities to carry out actions that are possible in authentic anaesthesia care. The symbols on the screen also have a great deal in common with the monitors in actual operating rooms. From the talk between the trainees, it is demonstrated that these refer to items such as *anaesthesia machines, drips, operating table* et cetera, as if they were real objects. As the symbols are easily recognisable and they may use a terminology that the nurses are familiar with, it can be assumed that communication is facilitated. Furthermore, the most important aspects to act upon are in the foreground of the interface, and there were few problems of finding proper ways of managing the functions in the simulation. The software also provides guidance by means of explanations of what the users are supposed to do in the preoperative phase, i.e. which actions to carry out and the sequencing of these actions.

Representations: According to Kolodner and Guzdial, the representations in the software are decisive for how the collaboration will turn out. That is, how they function as a foundation for discussions and further elaboration. In the software in this study, there is a model of the human physiology, which is represented by readings on tests, monitors et cetera. These representations can be looked upon as a selection of data provided in authentic anaesthesia situations. Feltovich et al (1996) argue for the value of multiple representations as offering increased opportunities for discussion. These discussions, they mean, can provide opportunities to overcome oversimplified forms of understanding:

> In particular, an example where there is a need for an alternative explanatory framework involves system levels of biological systems – because of multiple, simultaneous processes, co-dependent causality, synergistic effects, and so fort. (p. 32)

In the training session described above, the software obviously provided sufficient data to elicit intense discussions about problems relevant for the practice of nurse anaesthetists. As described in the low-blood-pressure-problem, the representation also offered a situation that was complex enough to be regarded as a realistic problem. Of course there are limitations in how human responses can be represented. As demonstrated in the session described, the selection of parameters represented in the interface directed the trainees' attention to central aspects of the causes of the simulated patient's physical condition and for further medical actions. Using feedback from the simulation, the trainees could see the effects of the actions carried out. In the session presented here, however, they were not able to fully understand the underlying relationships. Even their use of the available *physiology* and *effects of drug* functions, did not in this case indicate any contributions to arriving at such an understanding. The circumstances in this particular session did not invite the experimentation with different alternatives, which might have provided an opportunity to achieve a deeper understanding of the relationships between the different dimensions. However, the simulation seems to have a potential to demonstrate the ill-structured and complex nature of the knowledge domain. Since the participant's discussions were largely focused upon this complexity, the simulation can function as a tool for its management.

Function: By confronting the trainees with realistic case scenarios that promote sense making and inquiry, the simulation provides opportunities for the discussion of central aspects of the practitioner's work. The software functions as a common object for their attention and serves to structure the learning activity. When the trainees were running the simulation (in the implementation phase), their attention was primarily focused on the responses of the simulated patient. The patient's condition was then the point of departure for determining what actions to carry out. For instance, the low blood pressure triggered a discussion of possible causes, such as how to manage the problem and how to act on it. Their ways of handling the problems that occur, in turn elicited new simulated patient responses that had to be managed. In conclusion, both activities outside the current setting and the simulation itself, in the prevailing situation, provided the means for the framing of the task, which are thus means that can be regarded as different forms of structuring resources (Lave, 1988).

There is another function of the simulation, not in fact considered by Kolodner and Guzdial. In this case the software in a significant way mediates an understanding of situations and events in the trainees' work practice. They are, as demonstrated, not focusing on the underlying model in itself. Rather, their attention is directed to as to concern authentic patient problems. In the situations studied here, the simulation functions as a mediational means, to use the terminology of Wertsch (1998), in two ways. First, it is mediating between the participants and the work practice. The software presents issues of how to handle problems common to the nurse anaesthetist's work. As feedback is provided, an understanding of human physiology, as well as effects of drugs and other interventions, is possible. Second, objects and processes in the software are used by the participants as a means for communication. Utterances like *what is happening here*, pointing to the figures displaying the decreasing pressure of carbon dioxide in the expired gases, was enough to elicit a common attention to ventilation problems. That demonstrates how the simulation-based learning environment can, in a way, afford possibilities to use mediational means such as linguistic and physical artefacts, in the culture of anaesthesia practitioners. In that way trainees may learn their use in that culture and the training in the simulated practice could contribute to transparency in the sense that Lave & Wenger (1991) use the term. This however presupposes that the trainees are familiar with the culture or have access to an experienced anaesthetist, since the simulation per se does not provide the conceptual tools of the culture.

Concluding remarks

By using the concept of structuring resources (Lave, 1988) focus is directed to how the trainees and the teacher made use of experiences from work practice to frame the situation at hand. This framing was necessary to make sense of the case scenario that was initially presented. It was also necessary for the trainees to be able to come to an agreement as how to act with respect to the case and the events unfolding in the simulation. The simulation, in turn, also functioned as a structuring resource as such, as it structured the participant's activities within the educational setting.

The results indicate that training with the simulation influences collaboration and goal directed learning in significant, if somewhat contradictory, ways. The simulation provided a common ground for collaboration directed to highly relevant aspects of the anaesthetic nurse's work practice, such as balancing the administration of different drugs and other medical interventions in relation to the unfolding condition of the simulated patient. The simulation offered feedback on the interventions carried out and thereby possibilities for the trainees to draw conclusions on co-dependent causality and synergistic effects. On some occasions, however, it was not possible for the trainees to understand the dynamic processes. A reason for that could be the difficulties of keeping track of the different actions and their plausible effects, as those interventions were sometimes the results of compromises grounded in the rather limited and divergent experiences of the trainees. This, however, is the result of the nurse's first training session, after just one week of their practice period, and the outcome could be different when they accumulate experiences that are more comprehensive. As hypothesised by Feltovich et al. (1996), learning of complex knowledge domains is difficult because of the reliance on single analogies.

The participants' talk about the objects symbolised in the simulation, and the imagined patient, as well as the unfolding events, demonstrated that the problems in the simulation were looked upon as realistic. This feature of realism in the training was disrupted, however, by the structure of the educational setting. Here, three nurses collaborated on an equal level on tasks, which in work practice, are carried out within a hierarchy with a certain division of labour. In work practice, the team members have different roles and responsibilities, and the flow of activities is not an object for negotiations to the same extent as in an educational setting. Although this study demonstrates instances of how a simulation-based learning environment gives rise to insights and solutions that would not have come about without collaboration, there are also instances of how the authenticity of the situation is disrupted by the collaboration process as such. By using the terminology of Schön (1983), one may conclude that collaboration in the educational setting implies a shift in focus of the learning process from *reflection-in-action* to *reflection-on-action*, as the trainees take up a distanced position in relation to the simulated problems.
One further issue, in analysing data from the entire study, is in which ways a simulation-based learning environment, as a form of simulated practice, can improve goal directed learning by affording an arena for trainees to make use of structuring resources of real work practice. In a wider sense, this could elucidate whether a simulated practice can contribute to learning in the terms of Lave and Wenger (1991), i.e. a movement from peripheral participation in communities of practices to an increasing participation and involvement.

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7. The Development and Evaluation of an Enquiry Based Virtual Learning Environment

Charles Docherty and Helena Topp

Introduction

The department of nursing and community health at Glasgow Caledonian University is committed to the integration of problem based learning into the curriculum. The appropriate use of technology as part of the PBL process is central to maximising the learning that can take place within the Clinical Simulation Lab (CSL) and within clinical areas.

Recent U.K. Government commissioned reports are having a major influence on educational policy. The Dearing (1997), and Garrick (1997) reports, together with the Lifelong Learning Agenda and changes in student financial support all suggest that educational provision must be increasingly student centred. It is also envisaged that within 10 years the majority of students will experience the delivery of course materials through computers, and that much of the organisation and communication of course arrangements will be conducted by computer. This technologically focussed vision of the future, although desirable for efficiency and perhaps cost-effectiveness, needs to be operationalised with caution, for, as Laurillard (1993) explains, no single example of learning technology is capable of supporting all the main elements of learning. An integrated approach to utilising technology with other methods of learning within curricula, as advocated by Draper et al (1996) and Gunn (1997), would seem to be required. Strategies designed to realise Dearing's vision therefore require to take account of the strengths and weaknesses of different approaches to learning, and computers selected for applications to which, through evaluation, they are shown to be best suited.

Formal utilisation of problem based learning within curricula can be traced to medical education as a direct result of medical students inability to link academic theory with practice orientated problems, (Barrows and Tamblyn 1980). As a result, Barrows became involved in designing and evaluating a medical curriculum at the McMaster University which promoted small group, student-centred learning strategies, (Barrows and Tambyln 1980). Problem based learning continues to evolve (Bjork, 1999), and increasingly is enhanced by the use of educational technology.

Laurillard (1993) argued that to maximise learning, there is a need to exploit a range of educational media in combination with teacher-student dialogue, acting as a learning support mechanism. Educational media can range from print, television and video, to those emerging from information technology including computer tutorial simulations, intelligent tutoring systems and computer conferencing.

Von Hentig (1996) and Laurillard (1993) highlighted a role for technology as a necessary stepping stone between traditional classroom learning and hands-on practice, especially in relation to problem solving activities. Resnick (1987) also proposed the use of simulation, as a bridging apprenticeship between academic and real worlds. Hay (1993) and more recently, Collis (1996) have extended the notion of learning technology as a connecter, by implying that computers can connect students to each other and to other services such as the internet, e-mail, or facilitating learning through dialogue. Integration of computers into higher education departments and provision of learning support are local and regional issues but have now taken on a national dimension, with the publication of the Dearing and Garrick reports (1997).

Implications for Course Delivery

The strengths and weaknesses of computer courseware for both teachers and students have been emphasised by Proctor (1992). Strengths included self directed learning and repeatability of programmes. The path a student follows through a programme can be traced, giving teachers some awareness of how students have achieved learning, and a standard can be set within a topic. The main disadvantage identified was that computer programmes are often added on to existing curricula, and may be perceived as remedial to the learning process, (Proctor 1992).

The threat that teachers have felt in relation to technology has been identified both by Proctor (1992) and Koch and Rankin (1987). Ackerman (1982) prophetically suggested that teacher acceptance is the greatest challenge to any increased use of technology in education and held the same opinion as Laurillard (1993) that using technology does not necessarily mean less human involvement. Saranto et al (1997) support the idea of using a computer as a tool for learning. In a study of computer literacy development in Finish nurse education, a recommendation for developing the skill of communicating via electronic mail was supported by Saranto et al (1997).

This paper describes a proposal to develop and explore the integration of learning technology within one context where computers are identified as the preferred solution, and evaluate its effects.

Aims

This project aims:

i) to develop an interactive computer based system which delivers flexible, self-directed learning in the clinical simulation laboratory,

ii) to initiate the process of integrating learning technology into existing curricula within the nursing department of a large Health Faculty, and

iii) to explore teaching and learning roles compatible with an integrative approach to utilising learning technology.

System Development in Context

This educational innovation proposes the development of an interactive computer-based system to support the delivery of Problem-Based Learning (PBL) Case Studies for use in a Nursing and Community Health Clinical Simulation Laboratory (CSL). This is the first in possibly a series of developments that could transform existing curricula through integrating educational technology with traditional teaching methods.

The system will initially be developed and piloted in one module, in Year 3 of the Adult Branch, Higher Education Diploma in Nursing Programme, then cascaded to other modules following rigorous evaluation.

This development is intended to benefit staff and students within this department by incorporating the potential for customisation at the design stage, and by exploring alternative means of delivery to suit the needs of the range of modules and programmes that could utilise the CSL.

System Design and Production

A system to support students' self-directed learning in the CSL will be developed and formatively evaluated between April and September, 1999.

This pilot system will be constructed in Authorware for Macintosh. This authoring program is familiar to the development team, and will produce a workable framework which can then be made more sophisticated with other tools, tailoring the programme to the requirements of the simulation laboratory that has both intranet and internet facilities.

During September, 50% of 160 students (n=80) will begin the module studying intensive care for 6 weeks, then swap with the remaining 50% who begin by studying care of the elderly topics.

During each week of the 6 week Intensive Care Unit (ICU) component, the students will each:

i) attend a one hour lecture : notes to be posted on the network
ii) attend a two-hour PBL discussion group, exploring an unfolding scenario involving an ICU patient (group size; 16-18).
iii) in groups of 4, will book a one hour session in the CSL at a time to suit themselves. Their activities will facilitate the development of cognitive, psychomotor and affective skills through interaction with the computer and the elements of the scenario. It will be required that at least once in the 6 weeks, students will video an aspect of their CSL experience and present an analysis of this in their PBL discussion group.

System Evaluation

A multidimensional and flexible approach to evaluation is needed which takes into account how well learning technology and problem based learning elements are integrated within the virtual learning environment. This is an approach used widely in CAL evaluation (Draper 1997; Draper et al 1996; Rushby 1997). Formative evaluation will be an integral part of system development. This will be on-going, with a variety of methods used, such as field trials, focus groups, and expert panels, as recommended by Tessmer (1993).

The currency and accuracy of content has been assured by using practising clinicians and clinical consultants throughout. Face validity of the educational approach involved lecturers and specialists in education and learning technology. Student acceptance and implementability will involve field trials and focus groups.

This varied approach to on-going evaluating is best suited to informing and directing system production, but it also provides useful information on user-friendliness and implementability. Data is collected from participants ranging from the subject novice and the technically naive, to subject and technical experts. Although this formative evaluation is indispensable during the process of program development (Tessmer, 1993), there will remain a need to evaluate how well the system actually achieves its stated aims and projected learning outcomes with the students.

Evaluation of the Project Aims and Modular Learning

Examining how well the project achieves its aims and projected learning outcomes is a crucial part of quality assurance within the department and of further research. A key question within this project, is how well does a virtual environment support a real environment? The following evaluation instruments will be used as part of the evaluation strategy for this learning system within an acute nursing module.

1. Pre & post questionnaires and reviewing clinical objectives

Questionnaires will provide an overview of learning experiences associated with current learning situations for 160 students. Initial review of prior knowledge and experience by students is crucial to developing further understanding. Students will be asked to look critically at their initial interpretation of learning experiences which can be utilised within the forthcoming problem based learning module.

The questionnaire will also include an item which considers how new understanding is used. This will be designed with teachers in the module and based on a modular learning opportunity (eg, how would you assess a patient with respiratory problems). Answers will demonstrate how well the subject is understood, by asking students to write about it over a period of time. The questionnaire will be given to 160 students before and after each module, then again to selected students during subsequent clinical practice. The quality of written evidence can be gauged, as the student makes the transition from the academic to practical contexts. The level of understanding will be assessed by utilising the SOLO (structure of the observed learning outcome) Taxonomy (Biggs and Collins, 1982). This tool identifies language use with student questions and answers.

Students are issued with a clinical assessment document constructed utilising Benner's Domains of Nursing Practice (Benner, 1984), and utilising an adapted Criterion Referenced Rating Scale originally constructed by Bondy (1983), which, in its original form has been demonstrated to be both internally consistent and reliable (Bondy 1984). One learning objective particularly relevant to this module has been selected to consider how its achievement has helped a student to become part of the clinical community (ie, examine the student and mentors' comments about the objective and therefore give some indication of "the tension between competence and experience", (Wenger, 1998)).

2. Video analysis

The clinical simulation laboratory is equipped with video cameras and microphones above each of the 20 beds, able to be controlled remotely. Students will be asked to video record aspects of their performance and present this to their peers as the focus of discussion. The group responses and interaction will be unobtrusively recorded on audio tape for later analysis. From the data, learning agents and representatives within the community will be identified, together with learning developments which have been shaped as a result of this practice experience.

3. Reflection

To establish how reflection was utilised in the module, the following will be reviewed:

PBL Evaluation Questionnaire
This has been developed within Glasgow Caledonian University, and contains items that focus on facilitation, resources, and learning. It has established face validity, and has demonstrated internal consistency when used with a previous group of students (n=109); Guttman's split half technique = 0.87.

On-Line Quiz
Each week students have the opportunity of testing their knowledge and understanding in a multimedia, multiple choice quiz based on the activities of previous weeks. This will help provide continuity as the intensive care scenario unfolds. It offers some element of competition between student groups and a firm focus for learning.

On-line asynchronous question forum
This is designed to encourage students to verbalise and summarise the main elements of learning within the clinical simulation laboratory, and to identify issues worthy of further discussion within a larger group. An essential element of this process is reflection.

4. Comparative analysis

Comparative analysis between this cohort and a previous cohort offers some unique opportunities. The majority of the teaching and learning variables are the same; the learning scenario, teachers, the PBL approach. The only differences of significance are the introduction of learning technology within the clinical simulation laboratory, and the passage of one year.

Comparative analysis can be made in following three ways:
a) Through analysing quantitative data gathered using the PBL questionnaire earlier described. Responses of 109 students from the previous cohort can be compared with responses of the next cohort, n=160.
b) The practical learning outcome, as described earlier, can be used to compare how well previous and current students achieve this outcome.

c) Comparative analysis between this intensive care module and a mental health nursing distance learning module. This recent development within the department involves a PBL approach, regular face-to-face workshops and a computer conferencing system with synchronous and asynchronous communication.

Developing a Conceptual Basis for an Evaluation Framework

Developing a conceptually based evaluation framework for virtual environments is now essential not only to inform and direct the project at the focus of this paper, but to provide a clear means of analysing and interpreting future projects as educational technology expands. Most approaches to evaluation involve developing or adapting one or more of the widely available instruments, as described in Stoner (1996), e.g., observation logs, or attitudinal scales. Both quantitative and qualitative data may be collected. This 'pick and mix' approach to evaluation does not overtly acknowledge the concepts underpinning the strategy being used.

In addition, two inter-related issues require to be addressed in the development of an evaluation framework; the educational models in use and the facilities available. Educational programmes are driven by the educational model which underpins course delivery, learning processes and outcomes, and these in turn are heavily dependent on the nature and quality of the resources available.

Before discussing the proposed conceptual framework, therefore, a brief account of relevant educational models is required.

Educational Models

Laurillard's conversational model (1993) has been widely quoted as a trigger for developments with learning technology (Holyfield TLTSN Case Studies III; Draper 1996; McKendree and Mayes 1997). In simple terms, the conversational model highlights a dynamic and complex process involving teacher-learner discussion and feedback as central to the learning process. Holyfield points out how conferencing or email can replace or support face to face discussion and feedback, and, interestingly, does not see peer-peer interaction as part of Laurillard's model but views it as a way of showing how and where learning technology can be part of interaction.

Mayes (1995) and McKendree and Mayes (1997) discuss the learning experience as a conceptualisation cycle. This involves three phases; interacting with learning content (conceptualising), applying knowledge (constructing) and testing understanding (through dialogue). This model fits well with a resurgence of constructivist views in health care education, especially those associated with problem based learning, (ie McMaster, Maastrict and Australian models). Like Laurillard (1993), McKendree and Mayes (1997) highlight the importance of reflection within the learning process. Developing an ability to reflect on decision making and practice (Schon 1987) has long been viewed as a key element within professional and academic education, which includes nursing.

A learning model which supports problem based learning and constructivism, (Savery and Duffy 1996) is identified as enquiry based learning. Presenting a paper at a recent Conference on Learning and Collaboration in Virtual Environments (University of Jyvaskyla, Finland 1999), Professor Duffy identified characteristics associated with situated learning ie coaching and scaffolding, then linked these to enquiry based learning. Learning technology was viewed as a means of supporting enquiry. The enquiry process was described as having three stages; exploring (divergent thinking), analysing (individual reflection) and deciding (involving compromises within groups). Professor Duffy emphasised the importance of placing learning technology within educational structures, through the phrase, ‘invisible technology, visible pedagogy’. Barab And Duffy (1998) have highlighted a growing academic interest in developing the notion of learning communities through the term ‘Communities of Practice’, as have Lave and Wenger (1991) and more recently Wenger (1998).

Making effective use of available facitilties

As problem based learning is a growing feature within the nursing department where this research occurs, taking notice of how problem based learning underpins and is integrated within a traditional curricular format is necessary. The following questions need to be answered in order to indicate the current situation within the department.

How is problem based learning used in different courses?
What PBL model (s) is evident ?
At what stage of development is PBL integration within the department?
How are disciplines associated with nursing affected?
How is problem based teaching/learning being evaluated?
What is the role of learning technology within the department?
Some, but not all of these issues are addressed by the current development.

Developing an Evaluation Framework

Laurillard (1993) emphasises the importance of feedback and discussion for learning together with the development of relationships, for example, student-teacher, but also student-student. The process of reflecting upon experiences is also crucial to learning. For Mayes (1995), and McKendree and Mayes (1997) significant components include interacting with content, applying knowledge, testing understanding and reflecting upon experiences. Duffy (1995, 1999) suggests that the exploration of the learning situation and experience involves the elements of analysing learning needs, coaching critical thinking, reflecting upon experiences and the decision making processes within groups.

Prominent concepts from the three educational models presented have been identified. These concepts were rationalised into three evaluation themes including

i) Roles and relationships
ii) Learning effectiveness
iii) Reflective processes

The evaluation framework was initially derived from extending Duffy's concepts of explore, analyse and decision making as follows;

Exploring	What knowledge and experience do students/teachers bring to a learning situation and how is it used?
Analysing	Analyse practice, affective and cognitive domains
Deciding	Review group decision-making process through reflection in action and reflection on action.

These enquiry concepts are useful as they encapsulate the essential, basic elements of PBL regardless of which specific model is used.

Mayes (1995) conceptualisation cycle was also reviewed to incorporate enquiry/problem based learning and the four evaluation themes identified. This further refinement process resulted in the following three stage evaluation framework which is called 'conceptual evaluation'. As the central focus for evaluation, this is derived from the conceptualisation cycle and links to learning relationships and the value of vicarious learning (Mayes 1995; McKendree and Mayes 1997, Wenger 1998).

Three Stages of Conceptual Evaluation

1. Conceptualisation support stage to:

- establish evidence of prior learning experiences and content knowledge
- establish evidence of types of relationships and roles within an innovation, ie. between students and teachers and within student groups
- establish evidence of the value of the innovation/learning community.

2. Conceptualisation stage to

-establish evidence of learning effectiveness; understanding and learning transfer.

3. Re-conceptualisation stage to

- establish evidence of reflection in and on action, and advanced self monitoring skills.

Diagrammatic representation of the Conceptual Evaluation Framework

1	Roles and relationships	Conceptual Support
2	Learning effectiveness	Conceptualisation
3	Reflective processes	Re-conceptualisation

Conceptual Evaluation is designed to be flexible and applicable to both formative and summative evaluation requirements.

The Conceptual Evaluation Process

Evaluation Methodology	Conceptual evaluation
Project Description	Innovation Educational Approach Innovation Progress Team Members Field / Pilot studies
Evaluation Focus	Formative
Educational Focus	Roles and relationships Learning effectiveness Reflective processes
Evaluation stages	Conceptual Support Conceptualisation Re-conceptualisation
Evaluation Tools	Select tools with project team members Apply tools to first three stages
Data Collection, analysis	Develop an individual plan of action for project formative/summative evaluation data collection and analysis

Conclusion

This paper has reported the design and production of a computer facilitated, PBL orientated simulated clinical environment designed to foster practical skills of nursing students. The main emphasis of the paper is on the development of an evaluation strategy to support this project. Criteria for evaluation within this extended virtual environment were based on educational models in use and available facilities within one large nursing department. This evaluation criteria directed the development of an evaluation framework called conceptual evaluation. Testing out this framework is currently underway using two PBL and learning technology related innovations, as highlighted in this paper.

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8. Teacher’s Role in Supporting Project-Based Learning in Technology-Supported Environments

Helena Rasku-Puttonen, Anneli Eteläpelto, Maarit Arvaja and Päivi Häkkinen

Introduction

Much of the research on collaborative learning has focused on student interaction, but we must also recognize the powerful influence of the teacher on student collaboration. We need more knowledge about which are the most successful ways to support productive collaboration at different stages of project work, what kind of specific help should scaffolding include and what is the specific criteria for gradually reducing support. The present study aims to investigate how the teacher endeavours to promote collaborative learning in project work and how this in turn impacts on the processes and outcomes of the shared work of students.

This study was carried out in the context of an authentic science learning inquiry, where lower secondary school students worked in a network-based Globe environment involving them in laboratory experiments and analysing and reporting research findings. The results indicated the critical role of the teacher in the promotion of productive collaborative learning, a role that entails offering proper instructional support, reframing argumentation and fostering shared problem-solving and thus modelling an expert-like way of critical reasoning. Our findings revealed that many problems of collaborative learning were related to how well the teacher is able to offer proper support in appropriate moments and to their awareness of students’ thinking processes. Results concerning teacher role are discussed in relation to two factors, time and the organisational structure of the traditional schooling context. The paper also includes a discussion of students ability to communicate their need for help.

Theoretical Background

Recent research on learning and instruction has emphasized the positive effects of social interaction on learning (e.g. Light et al., 1994). Embedding learning tasks in authentic environments has also been considered important (Laffey et al., 1998; Lave & Wenger, 1991). Students' participation in scientific discourse and collaboration is assumed to provide them with learning and performance skills of the kind needed outside the schooling context.

It has been suggested that project-based learning should promote discussional and collaborative ways of working. Blumenfeld and others (1991) have described project-based learning as being centered on relatively long-term, problem-focused, meaningful instructional tasks. Students are required to organise and work idenpendently on a project, they must collaborate with peers and find resources in order to achieve high-quality outcomes.

Projects have the potential to enhance deep understanding because they oblige students to acquire and apply information and formulate plans, track progress and evaluate solutions. However, project-based learning is not without problems. It is known that group work may diminish individual students' mental efforts by encouraging reliance on others as resources, thereby undermining personal responsibility, deep thinking and critical evaluation of one's own work.

Engaging in project-based work requires many skills. Students may lack such skills as are needed in collaborative work. Working with others requires that one is able to discuss ideas, communicate clearly, consider alternatives, monitor one's own understanding, compare one's point of view with that of others and ask clear questions. Project-work presents special challenges to students. Earlier studies have, in particular, indicated that one important conversational skill that students often lack is asking questions that evoke elaborated explanations (Katz 1995).

Thus, engaging in a project-based inquiry requires new skills and support systems. Students need support for maintaining their commitment to the project as a whole. Teachers also have an important role in ecouraging students to ask questions that trigger elaborated knowledge building.

In many empirical studies of collaboration, the quality of spoken language has been used as an indicator of high-level learning. Analysing children who worked in a small group on a variety of computer-based educational tasks, Mercer (1996) found three types of talk: disputational talk, cumulative talk and exploratory talk. Disputational talk is characterised by disagreement and individual perspective-taking whereas cumulative talk features a high level of agreement among the participants. Conversely, in exploratory talk critical challenges are met within a co-operative framework. Mercer considers explorative talk a prerequisite for higher-level learning.

Previous studies of group discussions have suggested that disputational talk and cumulative talk are far more common types of discourse than exploratory talk (Shepardson 1996). Our own research project (Arvaja 1999) showed that exploratory talk was present only when the students were working on concrete tasks, for example writing report. Exploratory talk seemed to be very sensitive to such factors as social relations between the participants and the symmetry of their social roles. Imbalance in these was connected with disputational and cumulative talk. Accordingly, creating a setting which prevents the emergence of such obstacles linked with the composition of the group seems to be an important task for the teacher.

The available research has neglected to elaborate the teacher’s role in computer-supported project learning environments. So far, some results indicate that the teacher plays a crucial role in helping students to construct new understandings. Light and Light (in press) reported that the role and style of the tutors were clearly a major factor in shaping learning outcomes in technology-based environments. In addition, the results of Shepardson (1996) indicated that the teacher’s work mostly involved negotiating actions and meanings with children. By contrast, children working in small groups negotiated actions and the sharing of materials but failed to negotiate meaning explicitly. So far, we have little knowledge of the most successful ways to support productive collaboration, of the specific help that such scaffolding should include and of the criteria for reducing support.

The present study aims to investigate how the teacher endeavours to promote collaborative learning in project work and how this in turn affects the processes and outcomes of the shared work of students.

The main problems of the present study are as follows:
* What kind of help do students need during project work and how do they communicate their need for support?
* How does the teacher scaffold or facilitate students’ learning process?

* What kind of support from the teacher helps students to achieve deeper understanding?

Methods

Learning environment

The present study was carried out during an experimental science learning project where lower secondary school students worked in an authentic context of scientific inquiry performing laboratory experiments and reporting their results. The aim of the learning project was to examine the phenomenon of autumn tints in leaves (in Finnish *ruska*). The project was a part of the international science project GLOBE, consisting of a world-wide database of environmental indicators and measurements. The students worked on the project for 2-3 hours per week for three months.

Data collection and analysis

A small group of four students were videotaped throughout the project. The students and their teacher were interviewed before and after the project on their experiences. For this paper we focused on analysing the data on the report-writing phase. The data gathered during the report-writing situation consisted of approximately three hours of video- and audiotaped interaction. The student-teacher discussions were transcribed for a more detailed analysis. The transcribed protocols were analyzed using Mercer’s categorization of the three types of talk (1996). The teacher’s role was examined by extracting and analysing those episodes that included exploratory student talk.

Results and Discussion

An analysis of the students’ talk revealed only a few occasions when they were engaged in exploratory talk, featuring critical and constructive reasoning and discussion, argued to promote deeper-level understanding and learning. The most common type of talk found during the project-writing session was characterised as uncritical sharing of knowledge manifested as cumulative talk (Arvaja et al., 1999).

An analysis of the teacher's role on those occassions when exploratory talk was in evidence revealed that he had a crucial role in facilitating such interaction. However, when numerous group activities are taking place simultaneously, this challenges both the teacher and students. The teacher's challenges include first the division of time between several groups working in different places. Secondly, the teacher should keep track of the progress of each group's work. Thirdly, in order to offer proper scaffolding the teacher should be aware of students' background knowledge.

During group work students need to monitor their understanding in order to become aware when tehy need help. In addition, they should be able to formulate their problems so clearly that the teacher understands their thinking processes. The folllowing extract demonstrates how the teacher attempts to grasp what has taken place in a group and how the students have so far tried to find solutions.

Ann: Teacher, please. We have a problem.
Teacher: So, how could I help you?
Ann: We don't know what are the findings derived from our measurements.
Teacher: Please, take the figures and try to examine them.
Lisa: How could we utilize them?
Teacher: Actually.... what is the function of the chloroplast for the plant?
....
Ann: Do we write that ...
Teacher: So,... The chloroplast doesn't remain there over winter, but...
[Ann and Lisa look disappointed when the teacher doesn't understand their question.]

The extract shows how the students try to explain what kind of difficulties they have in interpreting their laboratory measurements. The teacher seeks to help them to focus on relevant aspects of the phenomenon. For this purpose, he scaffolds the students by asking questions and negotiating meanings with them. In this way the teacher tries to frame the problem by referring to the findings of the experiment. This seemed to promote the students' endeavours to construct shared knowledge. As a result, the students gained a better understanding of why chloroplast is drawn away in autumn. In this episode there were only two participants present and both were committed to gaining a deep understanding on the phenomenon.

The following episode demonstrates how the teacher attempts to scaffold the students' negotiation of meaning. The teacher comes to the students and tries to monitor their strategy for solving the problem. In addition, he tries to scaffold their endeavours to draw conclusions from the empirical data.

> *[Teacher comes to the students]*
> *Teacher: How does it seem to you?*
> *Ann: We are trying to interpret these curves.*
> *Lisa: Yeah.*
> *Teacher: Okay?*
> *Ann: I wonder how this scale should be interpreted? Is it 700 here at this point?*
> *Teacher: Let's look. [examining the paper] Maybe, it could be that point.*
> *....*
> *Ann: No, it can't be.*
> *Teacher: Just a moment, please. This is 400, 500,...*
> *Ann: But it doesn't make any sense.*

The extract demonstrates the importance of the teacher's proper support for the students' negotiation of meaning. Before the teacher attended the situation, the two students had already critically discussed and tried to draw conclusions from their measurements. However, only one student, Ann, who was more interested in understanding the task, could make use of the teacher's help. Ann's endeavour to gain a deeper understanding was manifested in her critical evaluation of the results derived from the measurements taken using spectrophotometry.

An analysis of the specific conditions which triggered shared critical reasoning and knowledge building showed that such high-level interaction was present in situations where the students had to find solutions to complex and ambiguous problems. Ill-defined tasks of this kind seemed to help the students to make sense, explain and argue, while very simple and direct questions by the teacher failed to promote such shared knowledge building.

As regards the role of the teacher, our findings revealed the importance of their expertise in offering proper support at appropriate moments. The main obstacles to this were the teacher's lack of time resources for guiding several student groups working simultaneously. Additionally, the timetable of the traditional school is in conflict with the demands of long-term project work. It is in this context that the teacher faces the huge challenge of maintaining the continuity in students' work. Within these constraints the teacher also meets the further challenges of comprehending students' background knowledge.

As regards our subjects, because of the students' lacking ability to communicate their need for support to the teacher, ascertaining the students' actual level of understanding seemed even more difficult. As a result, the teacher seemed to lack relevant knowledge of his students' thinking processes and their actual problems. The teacher also seemed to have problems with identifying what had taken place before the scaffolding situation. In project learning contexts, teacher interventions are even more demanding than with traditional teacher-centred classroom activities. Long-term project-based learning requires the teacher to continuously keep track of students' progress in order to act as a facilitator and coach promoting student collaboration aimed at shared knowledge building and high-level collaborative learning.

Advanced learning technology should provide the teacher with increased opportunities to make students' thinking more transparent and offer additional resources for appropriate scaffolding. This would enable the teacher to pay more attention to maintaining student's motivation for sustained and active work on the task and support critical thinking among students by motivating them to explain their thoughts and also evaluate other people's thoughts.

The potential that network-based technology has to help teachers will be further elaborated in our next study, focusing on a history learning project. The collaborative environments to be analysed in this project are based on role playing and students' identification with historical figures. The project, a collaboration between two schools, is supported by the FLE (Future Learning Environment).

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9. Modern Media and Instructional Technology in Vocational Education: Some Experiences of the Diffusion of New Technology in Adult Education Institutions

Saija Mäki-Komsi and Eero Ropo

Introduction

The paper reports results derived from teachers' experiences of the implementation and use of novel information technology in adult vocational education institutions.

There were three basic premises motivating the study. First, there seems to be a hectic invasion towards the idea of information society (Castells 1996, 1997, 1998). This trend is global, although the major leaps are made within the western countries. The second trend is the change in organizational cultures towards more transient, lean and flexible project organization dealing increasingly with information (Lash & Urry, 1994). Third transition process is related to the prospects and limitations of new learning environments emerging both from new ideas in understanding and constructing curricula (e.g. Pinar et al., 1995; Moore & Kearsley, 1996) and the pressures of rapidly developing information technology (Kincheloe, 1995).

Technology has become an essential part of our daily life despite the fact that the technology itself has a double role. It is both a risk and an option in the sense of threatening to deskill people and forcing them to become learners again, and being a helper and tool in routine and sometimes even in more complicated tasks (see Castells, 1996, 1997, 1998).

Training organizations are currently confronting the pressures of change in this double role context (Jenkins, 1993; Verduin & Clark, 1991). The existing organizational culture and particularly the educational practices applied are being challenged by the ideas and products of the information society.

One major advantage of the new (virtual) learning environments is that it offers an access to studying without the restrictions of time and space (Giddens, 1991).

Students are no longer tied to the time of instruction or the physical context where it takes place. This may increase an individual's interest in studying and foster self-directed, autonomous studying which can act like a catalyst in enhancing learning processes in directing the construction of meaningful knowledge structures.

From a more critical perspective we may argue that current learning environments are not yet virtual enough. Information technology is rapidly developing software and equipment for wireless communications, particularly for accessing world wide web and other internet applications. In educational thinking we have proceeded from computer–based training towards network based learning and networked multimedia learning systems. All those applications are, however, in their experimental stage at the moment.

The purpose of this study, belonging to the so-called OpinNet project, was to investigate the teachers’ experiences of educational and cultural changes in the adult education institutions. Our initial assumption was that the institutional shift from traditional teacher dominated, face-to-face teaching to networked team-work, emphasing students' independence is not only a methodological or technological change, but also a cultural one (Kasvio, 1994). It affects and depends on the whole institution and requires a multi-level transformation of the practices and procedures as well as overall changes in the thinking of teaching, learning and studying. The change required can be described as a paradigmatic one leading into qualitative shifts in the ways of teaching, learning and studying and the practices, such as assessment and evaluation, connected with those. Because of the major transformation needed, it is obvious that changes in the teaching culture will be slow and gradual (Rogers & Shoemaker, 1971). We specified the research question to study teachers' experiences of modern instructional technology in adult vocational teaching and students' studying.

We describe first the methodology and some empirical results on teachers’ conceptions. The rest of the paper discusses the implications of the empirical results particularly from the point of the cultural change at the institutional level. We will also discuss the recommendations dealing with the future development of vocational education and possibilities of enhancing the institutional transformation into the age of information society.

Methods

The methods applied in the study were mainly qualitative, although survey method was also used. The data were gathered with interviews and a short questionnaire delivered to all potential respondents via email. The subjects were teachers in 15 different vocational programs representing about 20 different adult vocational institutions. All subjects (n= 160) were asked to respond to a questionnaire that was used to select ten subjects for a thematically structured interview. The selection of interviewees was based on the strategy of making maximal differences between the responses.

Results

The Double Role of Instructional Technology

The results of the empirical study on teachers' experiences suggest that modern instructional technology changes the teacher's role both as a teacher and as a member of the educational organization. New technology seems to direct teachers to act more as facilitators of learning or as a developer of meaningful learning situations than being in a traditional role of transmitting knowledge with direct teaching. Concerning the organizational role there seems to be increasing number of other obligations for teachers than instruction in a vocational institution. More than 2/3 of the subjects responded having a myriad other things to do, such as development and planning assignments, consultation, and memberships in different projects and boards.

The teachers are also in a key role when assessing the success of the new innovation, for instance, application of modern instructional technology or creating new learning environments. This seemed to create pressures for teachers to be active in adopting the technology. Quite often this pressure was so intensive that teachers got an impression of being forced to be active partners in the development work. However, in general and in most cases the teachers were motivated to be involved in this kind of development work.

Results showed that the schooling organizations had poor or fairly poor opportunities to give strategic support for the developers. The cultural climate and organizational structure was often rigid and reluctant to accept hardly any changes. Also the resources for developing (virtual) learning environments and utilising instructional technology were perceived as inadequate. This may be interpreted to mean that in many cases teachers were forced to do the extra work without any reorganisation in the daily duties. Lack of resources for developing distance learning applications was also found in the organisations where the subjects came from. Organizations were short of, for example, tutors, study material developers, and information technology specialists.

Technology was experienced to help in teaching in at least two ways. First, it was seen as a practical tool that helps students to produce the demanded contents (texts, graphics etc). Secondly, it was seen as a new communication tool and a way to differentiate the content, context and awareness. All organizations were at the beginning or in early phases of integrating the technology in teaching. The results showed that the use of technology was more like experimenting with the network to do things differently and making efforts to communicate and interact through the network. All interviewed teachers had good visions of how, why and when to use technology. However, in most cases they thought that those visions did not come true.

One obstacle in the process of developing new culture seemed to be the institution itself. In many cases, the institutional culture and hierarchical organizations could not be changed to offer alternative ways for developing teamwork. There were only a few options for teachers to reorganise their work and duties. Those experiences were elaborated in myriad ways in the interviews.

Second obstacle seemed to be the inadequate infrastructure for students to study differently. In many cases it was only the school where the equipment and resources existed to be used for studying. The last but not the least limitations were the restrictive attitude and beliefs of the teachers and the learners. The interviews demonstrated that there was a common belief that in adopting new technology the question is more of changing the generation than learning new skills.

The interviews showed clearly that there are lot of pressures for teachers and institutions to develop teaching by adopting technology as an integral part of learning environments. However, the pressures accumulate historically in the situation in which instructional and learning theories have made major leaps even without technology being involved. Teachers have learned how to use teaching methods activating student learning. They have internalised the concept of context integration, started applying problem based learning (PBL), developed teaching models for enhancing students' more individual knowledge construction and so on. All this have to be transferred into new learning environments in which technology is the major participant. The theory and its instructional applications are yet to come. This may be one of the reasons for the teachers' unwillingness to take advances in applying modern educational media in their own teaching.

Supporting the Adoption of New Learning and Teaching Culture

The interview data showed that there are few common features in the organisations adopting new technology among the first ones. Those features can be summarised in five conclusions as follows.

First, organisations adopting new technology have already changed their instructional thinking from teaching students to helping them to learn. This attitude makes teachers to appreciate individual student processes and helps them to approach the goals and objectives the process itself creates.

Secondly, the organisations have developed explicit rules for the negotiations aiming at the shared understanding of the optimal learning environment for the students. The process of developing the rules takes several things into account. The history and old strategies of the organisation are among those.

Third, the members should have appropriate skills for using the equipment and seeing its potential in teaching and instruction. Fourth, the organisation should have proper infrastructure and related resources for adopting and developing individual solutions for applying the technology in the organisation. The fifth requirement for diffusion of technology in educational organisations seems to be related with the availability of support personnel for experimenting with the technology in instruction. This may mean the need to hire computer specialists, tutors, and computer lab personnel. There is also a need for people who have access to internet and email from home and who are willing to offer help to students regardless of time or day.

As a final conclusion we may say that the road to future is rocky, but promising. Teachers as key members of educational organisations are making true efforts to learn and change and results can already be seen in the new practices and applications. At the institutional level the change is sometimes painful, but there are no other options left. The world becoming increasingly competitive, market driven, and oriented by global trends has given the information technology a specific gloria in leading us to the new millenium. Educational institutions are assumed to cover the rocky road with a smoother pavement.

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10. Internet-based Training of Data Structures and Algorithms at University Education

Ari Korhonen and Lauri Malmi

Introduction

Helsinki University of Technology (HUT) is the leading technical university in Finland. About 1300 new students are enrolled each year, and over 200 start the computer science curriculum. In addition, most students from other curricula take several computer science courses during their studies. For example, the number of students which take the basic programming courses varies currently from 200 to 700 students per course.

Due to the vast masses of students on the basic courses we have used different telematic tools, like e-mail, newsgroups and world wide web for information delivery and communication over 10 years. In addition, several projects have been carried out for developing tools which aid studies, especially in the programming courses. One of such tools is the WWW-TRAKLA system, which we use for teaching data structures and algorithms (Hyvönen & Malmi, 1993; Korhonen, 1997). It is a specific tool for the delivery and automatic checking of algorithmic assignments. This tool is an integral part of the course and it enables us to provide assignments for the students in ways that were not possible when using human teaching resources. We can use personally tailored non-trivial assignments, give immediate feedback for the students and allow them to correct their answers. As a result of using such possibilities we have very good learning results.

The TRAKLA system has been used in HUT since 1991. During the first years all communication was taking place with it and the students were working by e-mail; in 1997 the Web-interface was added. Currently we are working in the LEAD project in which we develop a learning environment of data structures and algorithms. In the current project we have discussed a lot of the role of different telematic tools in education. Our experience shows that each of them can have their own roles which often partially overlap with the role of other tools. Moreover, we feel that standard tools like e-mail, newsgroups and WWW pages are quite sufficient for building a good learning environment. This view is somewhat contradictory to the current trend where integrated learning environments, for example, the WebCT tools, are being developed.

We agree that integrated environments have some problems which traditional tools do not have. First, the students have to learn a new system instead of using general-purpose tools which they use in their everyday communication. Secondly, some maintenance work has to be done by the teacher whereas a more obvious way would be to use system maintenance resources. Third, it is not so obvious how to add new facilities to these tools when the existing properties fail to meet the needs of a particular course. This holds in our case, since we necessarily use the TRAKLA system for the registration of students. Moreover, TRAKLA uses the standard tools for communication and we find no advantages of using it in parallel with some integrated tool. Actually we have concluded that what we need in our courses is a simple way of configuring an environment for each course separately, such that uses the standard tools and allows a loose interface for adding specific tools to the environment.

In this paper we address first the general needs for electronic communication in our courses. Then we discuss how various telematic tools respond to these needs. In section 4 we present our experiences about the WWW-TRAKLA system, and in the final section we discuss electronic communication in education in general.

General Communication Needs

In the following, we discuss the needs for communication from the point of view of basic programming courses since we have been developing their contents and organization for a long time. Most of the observations, however, have relevance also for other basic courses.

The basic programming courses in HUT include an introductory programming course (5 credits) followed by a course of data structures and algorithms (3 credits). The first course has 3 parallel versions, one of which is made for students in computer science curriculum and the other two are tailored for students coming from other engineering curricula. The second course has two

parallel versions. We have identified the following needs in communication between the students and the teachers.
The teacher needs facilities for delivering information for the students. This information includes, for example, the schedule and requirements of the course, supplementary course material, announcements, etc. Students need teachers' support and advice during their studies, and they also need to discuss with their fellow students. The advice and discussion can be either private or public. The teacher needs to collect feedback from the students. It is good to have a possibility to give anonymous feedback since some students may worry about their grades if they give critics concerning course contents or arrangements using their own name. The teacher sets up assignments for the students and they return their solutions and essays for evaluation. The evaluation can be made either manually or automatically. The students need enough feedback about their work. The teacher may want to allow students to read the work of other students, for example, in order to provide examples of good work or to allow the students to suggest critics for the work of other students.

In universities there are some practical limitations. First, human teaching resources are very limited. For the five courses we have in total 4 full-time teachers and several tens of student assistants. The teachers typically give the lectures, provide course material and organize the arrangements of the course, and the student assistants give guidance in the classroom exercises and during the office hours. Second, many students do not attend the lectures, either because they have other lectures at the same time, or because they want to study on their own. A number of students are working full time and therefore they take the course as distance education. Thus, we have a very different environment compared with traditional classroom courses.

Technical Solutions for General Needs

Various electronic communication tools are very useful for meeting the challengeS described. Since there is nothing new in our technical solutions, we present only briefly the role of e-mail, newsgroups and WWW in our courses. We also want to stress that although we discuss only the electronic communication, we have no aims of transferring the whole course into the Web. We have lectures, classroom exercises, and office hours for discussing personally with the students. The electronic communication only supplements these traditional teaching methods.

E-mail

We use e-mail especially for personal communication and advising. Each course has a unique e-mail address to which the students can send their questions. The student assistants read these e-mail messages and answer to the questions concerning the course. The students get the answers typically in few hours, or at the latest on the following day (excluding weekends). Since the number of messages is large, the teacher does not respond to these messages.

The student assistants direct some questions and comments to the teacher, if they feel they cannot answer them. Some students also send messages directly to the teacher, but we do not encourage this in practical programming problems. The teacher has no capacity for handling many such problems. When the students are working on their personal project, each of them is assigned a particular student assistant who guides their work, accepts the demonstration of the project and assesses the code and the documentation. Then, the student is given the personal email address of the assistant and they can communicate directly with each other without the extra delay caused by the course mail address, which is monitored by other assistants. Since we have a register of the email addresses of all students, we occasionally send a message to all of them. Such messages deliver urgent information, which should reach the students fast. In addition to weekly meetings with the student assistants the teacher gives guidance to them by email, too.

Newsgroups

Newsgroups are used for delivering annoucements and as an open discussion forum.

Each course has one or two newsgroups. In the latter case, one newsgroup is used for announcements given by the staff, and the other is used for questions of the students and for discussion. The separation into two groups has been useful since then it is easier to find the appropriate announcement messages afterwords. The discussion group is, of course, followed by the teacher and the student assistants. Occasionally also some other faculty members give answers and typically technical comments to the questions, although they do not belong to the course staff. When the teacher wants to give answers to email questions which are of general interest to students, he sends them to the discussion newsgroup in addition to the student who made the initial question.

WWW

World Wide Web is used for delivering information and collecting feedback. Each course has a home page which contains long-term information about the course, such as contact information, course description and schedule, guides for exercises and projects etc. Some information is delivered both in the newsgroup and on the WWW page, but typically long and complicated instructions are better presented in the Web.

Web is a natural tool for publishing supplementary material for the course. The results of the assignments and projects are published in the Web. However, we restrict this information so that it can be accessed from computers under the university domain only. We do not wish such pages to find their way into search engines like Alta Vista, e.g.. The students can send feedback from the WWW page to the teacher. During the course there is a simple feedback form using which feedback can be given anonymously. The teacher reads the feedback and responds to it in an appropriate way. Often the response is published in the course newsgroup together with the initial feedback text. At the end of the course, or at the end of some of the course, a feedback questionnaire is published in the Web. A simple script program is used for gathering the statistics about the answers.

WWW-TRAKLA System

In short, TRAKLA is a system which delivers assignments for the students, receives their answers and grades the answers automatically. The assignment are non-trivial in the sense that the students have to simulate the working of different algorithms and show how the given algorithms change the contents of data structures they handle. An example: "Insert the following keys in this order into an empty binary search tree, E X A M P L E T R E E. Show the final tree. Thereafter delete the keys R and X and show the final tree."

In the e-mail-based TRAKLA system the students send their answers by e-mail in a pre-defined format to the TRAKLA server. This arrangement has some obvious drawbacks. First, the students may loose points for trivial format errors which have nothing to do with the initial assignment. Second, most data structures are more naturally presented in a graphical form instead of some cumbersome ASCII- presentation format. In order to remove these problems, the WWW interface to TRAKLA was built in 1997 (Korhonen, 1997). It gives to each assignment a graphical editor which presents the data structures in their natural form. The students can solve the problem by using the keyboard and the mouse in the interaction.

Moreover, they can browse their solution backboards and forwards as a list of states of the data structure. Thus, they can ensure that their solution is correct before submitting it to evaluation. WWW-TRAKLA then converts the answer to the format understood by the TRAKLA server and sends the answer to it. A very important feature of the system is that we can generate a unique initial data for each student. Thus, although the basic assignment is the same for all students, they all have to solve a personally tailored assignment. This has obvious advantages for learning. They cannot copy their answers from anybody. Moreover, we can now encourage natural co-operation between the students. They can discuss the problem freely so far they do not solve each other's assignment totally.

A second, very important feature is that the system gives almost immediate feedback for the students after the submission. They get the grading and we allow them to correct their answers a few times, typically 3-5 times per assignment. This allows them to learn from their mistakes. We stress here that they have to think about their solution anew for each new submission, since the solution space of the assignments is simply far too large for using mechanical trial-and-error method.

After the deadline for submitting the answers we send the model solutions for all students by e-mail. Thus, they can check what was wrong, if they did not get everything correct.

For most assignments we provide hints in the web. We have also an exercise mode of the assignments. This feature means that the students can make free exercises on a given fixed data, submit their answer and get the model solution for that data. They can thus exercise on the topic before working with their own personally tailored data.

Experiences and Further Development

We have tried to find ways how various telematic tools could support best the learning process on our courses. In many cases we have been successful, since the students give good feedback to us and the learning results are good. In summary, our experiences about the standard tools are the following: The e-mail service works well in a mass course, when there are enough assistants for answering the questions so that we can guarantee fairly quick responses to questions and comments. This suits well to many students, who work at home and dislike coming to the campus at a certain time. The student assistants also like to work at home in the evenings. It is important to identify the responsibility strictly for each assistant. We have used both temporal sharing of responsibility, e.g., an assistant takes care of e-mail service for one week at a time, or responsibilities are related to certain topics or student groups in the course.

The e-mail service works only on small problems and on routine matters. In complicated programming problems face-to-face discussion is preferred. The teacher should limit his/her part in e-mail advising, since it is more difficult for him/her to guarantee quick response time. The newsgroup discussion is a useful tool both for the students and for the staff. The students send questions to the newsgroup and they often get the answer faster than from the e-mail service, since the more advanced students are willing to share their knowledge. Occasionally comments on some special topics are received from outside the course when other members of the faculty also follow the newsgroup.

A newsgroup suits well for getting immediate feedback from the students as well as for providing the teacher's comments for them. Www offers a nice way of organizing anonymous feedback from the students. Www is a wonderful tool for making questionnaires. If the students get some small advantage of answering the questions, very high percentage of them answers sincerely. The summary results are easy to publish in the web and the teacher can comment on them in the newsgroup.

TRAKLA has been a valuable aid for us. In spring 1998, more than 500 students have taken part in the course of data structures and algorithms, and each of them had to do some 25 algorithmic exercises using the system. These exercises covered most of the basic data structures and algorithms discussed in the course. The results were excellent. About 60 percent of the students received the highest grade of this part of the course which required them at least 90 percent of maximum points. The intermediate results of the next course seem to reach the same level. These results have convinced us as teachers that the students truly have learned the basic topics in the course and we could set up more advanced exercises for them. Last time the other exercises dealt with inventing new algorithms for small new problems and analyzing the working of simple algorithms.

In spring 1999, we gave to the students two larger design projects which they solved in groups consisting of 2-3 persons. In the first project they devised basic algorithms and data structures for a simple search engine for documents. In the second project they invented algorithms for a system with which a person can make queries about timetables and routes for public transport. For example, the task assignments might be as follows: "Give the fastest connections from point A to point B, and assess what bus rotes should be used". The students returned their designs as html pages which we copied to our computer. Then, we sent the same designs, i.e., the URL, after making them anonymous, for the evaluation for other groups. Each design was evaluated by five other groups and each group had to evaluate five designs, choose the best of them and write down their comments. The comments were returned as html pages and delivered to the original group, as well to us. In this way the students got a realistic view how difficult it is to present a solution in a readable form and what kind of problems are encountered in the evaluation. Since each work was evaluated by a number of groups, we could compare their evaluation reports in addition to the original work. Both parts, the design and the evaluation was graded.

Our experience was that the students learned a lot during the design process and during the evaluation. However, two such projects caused too much work for them. In addition, many students found the evaluation phase very difficult. Therefore, the evaluation reports were partly superficial and contained obvious errors. We concluded that we cannot use the students for grading each other's work. The teacher and the assistants have to take care of it. However, the students should read each other's work and give comments on them. The implementation of this phase was carried out by simple script programs since we did not have a tool for managing such operations.

Some Comments on the Learning Environment

The whole system we are using, including WWW-TRAKLA with e-mail, newsgroups, and www-pages can be considered a learning environment for data structures and algorithms. It seems to work fine and it also supports most of our needs. However, we are developing it further in the LEAD project. Essentially, we want to enhance the feedback that TRAKLA gives for the students. Currently it evaluates only a few intermediate states of the data structure, and it does not evaluate the process how the data structure entered this state. We shall add such a feature to the system, and then we shall be able to give better feedback where the error occurred in the solution. Then it is also easier to prepare simple commented animation examples of algorithms as supplementary material. With such tools we aim to build more electronic course material in the web. We are not going to include very much text in the new material, since a text book is a better tool for such representation. On the other hand, interactive exercises with feedback and commented example animations give some true extra value for using the environment.

During the development of our system we have had to consider what is the role of each telematic tool that we use. We could summarize our view in the following way.

First, before taking any actions of using electric tools, one should define what is the problem. Do you need anything new, or is the current traditional environment good enough for your needs? In our case the key problem was the number of students and how we can provide enough feedback for them and to enhance the communication between them and the teachers.

Secondly, if there is an obvious problem, one should use the basic technology for the needs. The students know how to use e-mail, newsgroups and WWW, and they like to choose their client to such system. We should not push them using new systems. In our case, standard email, newsgroups and www solved most of our problems.

Third, when standard tools are not suitable, one should try to find a working solution done by someone else. You probably will find it in the web. In our case, no such tools were available when we started with the TRAKLA project in 1990. If no other solutions exist one should prepare a new solution. Time and resources should be used for implementation, maintenance, and evaluation weather this pays for the advantages your claim to achieve. We do not see that any integrated learning environment currently available could solve our problems, since the key problem is the specific feedback for a special course.

References

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LEAD project home page. See, http://www.cs.hut.fi/~tred/LEAD/