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ABSTRACT

The purpose of this paper is to describe the pedagogical background and design rationale of ITCOLE (Innovative Technology for Collaborative Learning) software. The ITCOLE software is a highly scalable and easy to use modular environment that supports students' joint efforts to build knowledge together, whether they are primary, secondary, or older students. The central metaphor of the ITCOLE system is that of shared electronic workspaces that students and teachers use for asynchronous and synchronous collaboration. The system will provide tools for community building by providing real-time information on various aspects and mostly under open source terms for educational institutions. A downloadable pilot version of the ITCOLE server software under the title, Future Learning Environment 2 (Fle2) with some of the basic functionality, is currently available at http://fle2.uiah.fi/. (Contains 10 references.) (Author/AEF)

ITCOLE Project - Designing Innovative Technology for Collaborative Learning and Knowledge Building

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Abstract: The purpose of this paper is to describe pedagogical background and design rationale of ITCOLE (Innovative Technology for Collaborative Learning) software. The ITCOLE software is a highly scalable and easy to use modular environment that supports students' joint efforts to build knowledge together, whether they are primary, secondary, or older students. The central metaphor of the ITCOLE system is that of shared electronic workspaces which students and teachers use for asynchronous and synchronous collaboration. The system will provide tools for community building as well as include awareness tools that help users to manage their joint knowledge building by providing real-time information on various aspects of collaboration. It is intended that the ITCOLE software will become available free of charge and mostly under open source terms for educational institutions. A downloadable pilot version of the ITCOLE server software under title Future Learning Environment 2 (Fle2) with some of the basic functionality is currently available (http//: fle2.uiah.fi).

Introduction

According to international assessments, innovative learning technology based on the new information and communication technology (ICT) promises to lead to a new decade of the learning revolution (Roschelle & Pea, 1999; Pea, Means, Hsi, Tinker, Bransford, Brophy, Linn, Roschelle, & Songer, 1999). Collaborative knowledge building is one of the most promising innovations to increase quality of education with the help of modern collaborative technology. This pedagogical approach emphasizes the importance of engaging students and teachers in coordinated efforts to build new knowledge and to solve problems together (see Dillenbourg, Baker, Blaye, & O'Malley, 1996; Scardamalia & Bereiter, 1994). Several empirical experiments offer evidence that collaborative technology designed according to innovative pedagogical ideas facilitates higher-level cognitive and social interaction and deeper understanding (Pea et. al., 1999).

The key objective of the present project is the design and development of a modular knowledge-building environment (working title, the ITCOLE software) that supports students' joint efforts to build knowledge together, whether they are primary, secondary, or older students. The system will be designed to provide tools to facilitate the development of the students' skills of collaborating, engaging in various networked activities, solving increasingly complex problems in different domains of knowledge, and working productively with knowledge. The central metaphor of the ITCOLE system is that of shared electronic workspaces which students and teachers use for collaboration. Such workspaces are provided in a number of different ways since the functionality and the interface of the system will be derived from pedagogical considerations and can be adapted to the different school environments and contexts as well as used in conjunction with other pieces of software.

Even if there are hundreds of networked learning environments available, most of the available applications are not designed to facilitate in- depth learning or genuine collaboration between students (Stahl, 1999; Stahl, Hoadley, Slotta, Guzdial, & Suthers, 1999; Roschelle & Pea, 1999). Most of these systems have been designed to manage and deliver study materials or provide tools only for unstructured chat-like discussion rather than facilitate advancement of knowledge and understanding. From these environments, *knowledge-building environments* differ substantially; the latter, from the beginning, were designed to facilitate collaborative knowledge building within a local or virtual learning community (Scardamalia & Bereiter, 1994). Characteristic of knowledge building is to go beyond individual learning by pursuing together students' own questions and problems of understanding, generating, elaborating and discussing students' own explanations for the problems being addressed. An engagement in knowledge building focus on articulating, elaborating, and extending knowledge objects created by the participants (Bereiter, 1999). Various innovative tools and facilities are to be developed into the ITCOLE system that enable the users to construct, illustrate, share, analyze and synthesize their understanding while building knowledge together. Moreover, ITCOLE software will be an awareness-oriented collaboration system that provides users real-time information on several aspects of collaboration and helps them to manage the process of knowledge production and build their social community.

Extensive studies in authentic school environments reveal that practices of knowledge building have not yet been disseminated to European schools; teachers and students are currently not using the new technology intensively as a tool of learning (Lehtinen, Sinko. & Hakkarainen, in press). To successfully promote educational use of the new learning technologies, and at the same time implement new pedagogical and cognitive practices of learning and instruction, appears to demand the utmost of both teachers and students (Lipponen, 1999). The problem is that technical tools do not themselves provide teachers with adequate models of pedagogically meaningful ways of using them in various pedagogical situations. Educational researchers need to further crystallize and concretize pedagogical models of collaborative learning and knowledge building; implement these principles in highly scalable and easy to use learning environments; and make these environments accessible to teachers and educational institutions (Lehtinen et al, in press).

The project focuses on crossing boundaries between software developers, pedagogical researchers, and the users of knowledge-building technology – teachers and students. It represents a plan to integrate in an innovative way software development with pedagogical research and intensive field testing. The present project is based on a contention that through co-evolution of the technical tools and pedagogical practices, solutions are likely to emerge that really contribute on pedagogical change at school.

Description of the ITCOLE software

The research and development project of ITCOLE software is a part of European Community's Information Society Technologies (IST, Schools of Tomorrow) program 2000-2002. The design principles will be specified by piloting of the first working prototype of ITCOLE software as well as the participants' benchmarking experiences of other pieces of collaborative technology (CSILE, Future Learning Environment, Knowledge Forum, Telecommunicado, Virtual Web School, WorkMates and so on). Many challenges of designing ITCOLE software's user interface has been preliminarily solved in the design of Future Learning Environments (see Leinonen, Raami, Mielonen, Hakkarainen, & Muukkonen, 1999). A downloadable pilot version of the ITCOLE server software under title Future Learning Environment 2 with some of the basic functionality is currently available (http//: fle2.uiah.fi). The Fle2 server software has been developed in the Nordic Nordunet2 project (http://fle2.uiah.fi/project_plan.html). The Fle2 server software itself works on Unix/Linux systems, but for end-users (students, tutors and administrators) it is totally cross platform, usable with any computer or other device (palmtops, mobile phones), for which there is a HTML 3.2 compatible webbrowser and Internet connection. Although only some aspects of the learning environment have an adequate technical implementation, this environment can be used to evaluate and test pedagogical characteristics of ITCOLE software in different educational settings. The pilot studies will allow developers of ITCOLE software to go beyond current understanding of CSCL design principles and creating a next-generation pedagogical design for ITCOLE. In order to facilitate scaling up of good pedagogical practices of using innovative learning technology, it is intended that the ITCOLE software will become available free of charge and mostly under open source terms for educational institutions.

The specification of the ITCOLE System is focused on providing a shared multi-user environment to carry out computer supported collaborative learning. The system will be accessed through the Internet (TCP/IP) with any HTTP/HTML compliant browser such as Microsoft Internet Explorer or Netscape Navigator so that users normally will not have to install any software locally. In this way, access to the system will be platform independent and it will be usable across Microsoft Windows, Macintosh, Unix, Linux, TV Set-Top Box (Internet on TV), and palmtops, e.g., Nokia Communicator or Windows CE systems. (The system functionality is implemented through extensions to servers, primarily Web servers.) Thereby, it will provide seamless support for co-operation in heterogeneous environments often typical of educational institutions. The environment will contain several tools:

Virtual WebTop module (with folders and wastebasket). In the virtual WebTops the users may create documents, bring documents from the www and upload documents from local disks. With the Webtops the users may store and share these documents with fellow users. The Webtops may also contain several small educational applications (Java applets), such as calculator, simulations.

The Knowledge Building module facilitates between-user interaction and provides a means for conducting multiple discussions simultaneously within a course. Notes posted to the database are labeled with a 'Category of Inquiry' reflecting a step in inquiry process.

The Jam Session module encourages free flow of ideas and allows experimentation with different ways of representing knowledge. The Jam Session is a shared environment for collaborative construction of digital artifacts.

Meeting Rooms is an avatar world where avatars (pupil, tutors, and teachers) can immerse themselves In a 3-D experience and use the collaborative multi-user applications (whiteboards, chat, presenters and so on).

The Library module is designed to store, publish, and browse different learning materials (see the Tutorware) and student's works.

The ITCOLE software will be designed to provide external structures that help a student to participate in expert-like processing of knowledge without the increasing cognitive processing load. This kind of external support provided during the process of inquiry appears to enable students to solve more complicated problems than they would otherwise be able to do.

- Participation in in-depth learning will be facilitated by ITCOLE software's system for entering thoughts and ideas: the ITCOLE environment guides (scaffolds) the users in categorizing their computer entries and cognitive activity in a way that corresponds to fundamental aspects of inquiry learning; for example, Problem, Working Theory, New Scientific Information, and Comment. Furthermore, several sets of scaffolds will be designed for assisting learning of different subject domains (e.g., sciences and humanities) and specific purposes of a study project.

- ITCOLE will provide tools for students to record and visually represent their activities as they participate in inquiry learning. By using the tool, teachers and students can track and reflect on the progress of a project together as well as plan how to go ahead.

- A further challenge is to design such a kind of interface that helps the users to manage the knowledge they are producing (Muukkonen, Lakkala, & Hakkarainen, 1999). Frequently, relatively large number of messages in a learning environment's database makes it very difficult for the users to follow lines of argument or advancement of ideas. An important challenge of ITCOLE is to design tools that help to represent progress of discussions by graphical means, such as reaching milestones, reflecting activity, highlighting chosen items or summarizing prior work.

Design Objectives of the ITCOLE Software

The objective of the Interface Design is to build, for the ITCOLE system, a pedagogical interface for educational use. This objective can further be divided into three main aims: scalability, usefulness and usability. The three aims for interface design for the ITCOLE system are as follows:

1. Building a working interface that scales to various client platforms representing 80% or more of those used in typical educational, home and work environments (n.b. a set of minimum requirements for a client are a html standard capable browser, on-line internet connection and typical input/output device combination). This ensures universal access for different user/browser configurations.

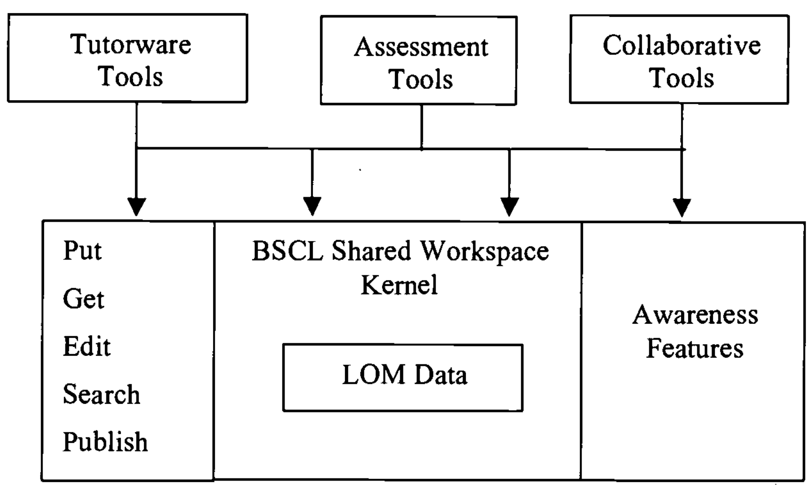
2. Incorporating a full set of features to enable collaborative knowledge building over the Internet into the interface, and coupling that with the functionality of the System implementation. This ensures the usefulness of the system for the major target groups in the field of collaboration.

3. The interface design process will place a strong emphasis on creating user-friendly and attractive graphical design and a graphical style, which is flexible and customizable by the user. This ensures that the level of usability in the system is high enough to support and sustain actual learning situations in a typical school environment.

For the development of the various components, strong emphasis will be put on modularity, so that it is possible to compile individual components for the various application scenarios to be used for testing and evaluation. In terms of increasing content sharing and future co-operation among different partners, the platform specifications will enable us to remove technical barriers of collaboration between applications. This objective will be achieved by adapting powerful standards, such as XML.

The ITCOLE System Architecture

Shared workspaces are the primary means of collaboration to be provided by the ITCOLE system kernel that relies partially on the BSCW system kernel (see http://bscw.gmd.de). The shared workspaces contain the persistent objects, which are needed for or created by the collaboration processes and support the construction and reconstruction of collaborative processes within specific work groups. The overall system architecture is shown in the following figure.



Objects in the workspaces can be accessed and manipulated, e.g., users may upload, download, edit or publish information. Around this kernel will be a set of additional features and tools, in particular tutorware, collaboration tools, assessment tools and comprehensive awareness features as described below.

Shared Workspaces

The primary features built into the shared workspace component of the ITCOLE system are as follows:

- The system allows the joint production of multimedia information in distributed environments. The system will provide tools for the users to collaboratively create, develop, discuss, and publish (hyper-) documents, or more generally, knowledge.

- The system provides information about what the individual persons of a group have done or are currently doing with respect to the collaboration processes supported by the workspaces. Towards this end, the system will provide comprehensive information about activities within workspaces, capturing various types of activities (events) and using various ways of promoting these events to recipients.

- Besides the textual representation of information, the system will provide graphical representations, e.g., for visualizing cross-relations between documents or lines of arguments in discussions, shown in varying stages of complexity, providing features such as "zooming in/out" of details.

- The system will support the publication of the results of collaboration processes, i.e., a read-only copy of (parts of) a workspace will be anonymously accessible over the Internet.

- The system will include components for organizing and managing the collaborative learning process similar to features found in workflow systems, e.g., the appointment of (one or more) moderators for particular tasks, the time scheduling of tasks, and the allocation of duties.

Synchronous collaboration tools

The shared workspaces are primarily targeted for asynchronous modes of collaboration; cognitive research as well as practical experience indicate that this form of collaboration provides the best support for extended and sustained working with shared ideas and knowledge objects in the context of a study project. Frequently, however, synchronous collaboration and co-operation is also needed to coordinate efforts of participants or members of a virtual team as well as to support building of a social community within the virtual learning environment. Synchronous communication provides a means for participants, who may not know each other very well beforehand, to interact socially, learn about each other, and engage in social bonding, thus creating the sense of community needed for engaging in intensive knowledge building. Applications as whiteboards, presenters, and chats are important elements for the communication within a group of people. These applications are based on the concept of data transmission to all collaborators. Combinations of these applications can result in a powerful tool with all the advantages of each single application. The following applications will be integrated in the ITCOLE tools:

- **Whiteboards** allow users to draw in a shared area, which can be visualized by all collaborators simultaneously.
- **Presenters** (or presentation software) facilitate the transmission of sequential images to all participants, for example, the presentation by slide show or a sequence of HTML pages. In addition, these tools must contain features that permit the highlighting of particular objects.
- **Chats** permit the written communication between all participants of a study group. They must indicate the name of the user that wrote the message, so other user can know who is talking.

To simulate conversational meeting, real-time applications must include features that offer characteristics similar to such meetings, for example presence awareness and activity awareness is the sense of the presence and general activity of group members. For instance, it is very important that a whiteboard, a chat or a presenter show the list of the actual collaborators. The tools for synchronous communication can be located in avatar-world. In general the scene represents a Meeting Room which avatars (pupil, tutors and teachers) can immerse themselves in a 3-D experience and use the applications (whiteboards, chat, presenters, and so on) available in the Meeting Room. Also some external tools, such as the Virtual Room Videoconferencing System (http://vrvs.cern.ch/) developed in CERN can be embedded to the Avatar-world.

Assessment Tools and Tutorware

In addition to the previous features which are directed towards collaborative learning environments, the ITCOLE system will also support more instruction based learning scenarios. Assessment tools will allow self-evaluation of students with respect to their learning progress and will enable feedback between students and teachers in this process. The assessment tools will be built on top of the awareness system and thus create a suitable infrastructure for progress tracking and learning improvements based on feedback information. These tools will use technologies developed in the field of artificial intelligence for the identification of students who are not actively participating, or who produce only fragmentary, episodic notes, instead of sustained dialogues of knowledge building with their fellow students. The assessment tools function simultaneously as a means for the tutor or teacher to monitor participation of students, to identify students and discussion that do not appear to advance, and to detect groups that are not sufficiently interacting or communicating among themselves.

Teaching courses are usually a collection of individual learning modules which have to be traversed by the students in a particular order. **Tutorware** will be used to create such courses materials to the system's Library. The tutorware to be developed will allow the adaptation to the requirements and interests of each individual student, depending on progress and performance during the visualization of the contents, i.e., the content will be made up both of the information that will be presented to the pupil in each single learning module and of the control mechanisms that tell the system how to guide the student individually through the courses. Tutorware will also support teachers in collecting and creating educational objects like simulations, problem-solving tasks or other teaching materials available on the Internet or through other resources.

Pedagogical Evaluation and Testing

In advanced pedagogical practices, the use of information and communication technology becomes an integrated part of the whole learning environment and the culture of learning. As such, technology is used to build up social structures that encourage learning and reflective discourse, and to help students and teachers gain knowledge as well as to deepen their understanding of different domains (Dillenbourg et. al., 1996). The evaluation process focuses on assessing how the ITCOLE software specifically facilitates learning in various educational settings, European countries and educational cultures. Field tests focus on developing and analyzing innovative ways of using ITCOLE software for facilitating in-depth learning from elementary to high-school level education. Case studies will be used to assess ITCOLE software's technical as well as pedagogical usability and functioning. The case studies will be carried out by setting up pilot versions of ITCOLE software in several classrooms in each participating country to be used alone or in conjunction with other pieces of software. Results of the field tests will continually provide feedback for the on-going design and development of ITCOLE software. The second part of field test involve experiments in scaling up networked learning, i.e., the investigators will examine and demonstrate, in collaboration with national school authorities, to what extent innovative models of networked inquiry learning can be scaled up beyond individual well-supported experiments across normal schools and teachers and students. The scaling-up experiments will involve a relatively large number of primary and secondary schools, several teachers from each school, and hundreds of students in several participating countries.

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