TECHNOLOGY ENHANCED LEARNING

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• The IFIP World Computer Congress, held every second year;
• Open conferences;
• Working conferences.

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TECHNOLOGY ENHANCED LEARNING

IFIP TC3 Technology Enhanced Learning Workshop (TeL'04), World Computer Congress, August 22-27, 2004, Toulouse, France

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Session 5: Fast Abstracts

Preface

Technology Enhanced Learning (TeL) has provided tools and infrastructure to education and training disciplines for over a decade. Main research issues include pedagogical and evaluation theories, integrated learning environments, e-learning experiments, trials and overall results from TeL deployment. Relying on recent experience and prospective results from R&D projects, in particular EU initiatives (e.g. Information Society Technologies –IST, Leonardo da Vinci Advanced Training Systems, etc), the Tel'04 workshop, organized on August 22 2004 within the 18th IFIP World Computer Congress, has given educational institutions, experts, practitioners and technologists an opportunity to share their experience.

All papers contained in this volume were selected through a rigorous peer reviewing process under the responsibility of an international program committee. Altogether 18 high quality papers (among them 6 long papers, 8 short papers and 4 abstract papers) were selected in this volume out of 51 submissions from around the world.

The papers are grouped into 5 chapters, corresponding to the workshop sessions: "E-Laboratories from Theory to Practice", "E-Learning Evaluation and Usability", "New Generation Technologies at School", "E-Laboratories Experiments" and a Fast Abstract Session. These chapters cover important issues of current research interest in Technology Enhanced Learning.

We are grateful to the authors for submitting the papers, to the reviewers for their efforts in making good detailed reviews on time and to the Program Committee for establishing the final program. We are also grateful to Prof. Jan Wibe from the Trondheim Norwegian University of Science and Technology and current chair of IFIP Technical Committee 3 on Education for his invited talk on E-training in Norway. Special thanks are due to the Tel'04 organization committee and to his chair Dr. Pierre de Saqui-Sannes. Finally, we would like to acknowledge the support of the IFIP WCC'04 Organization for making this workshop possible.

Toulouse and Athens

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Session 1

E-Laboratories from Theory to Practice

THE LAB@FUTURE PROJECT
"Moving Towards the Future of E-Learning"

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Abstract: This paper presents Lab@Future[1], an advanced e-learning platform that uses novel Information and Communication Technologies to support and expand laboratory teaching practices. For this purpose, Lab@Future uses real and computer-generated objects that are interfaced using mechatronic systems, augmented reality, mobile technologies and 3D multi user environments. The main aim is to develop and demonstrate technological support for practical experiments in the following focused subjects namely: Fluid Dynamics - Science subject in Germany, Geometry - Mathematics subject in Austria, History and Environmental Awareness – Arts and Humanities subjects in Greece and Slovenia. In order to pedagogically enhance the design and functional aspects of this e-learning technology, we are investigating the dialogical operationalisation of learning theories so as to leverage our understanding of teaching and learning practices in the targeted context of deployment.

Key words: Activity theory, synchronous and asynchronous learning, mixed and augmented realities, e-learning laboratories.

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1.   INTRODUCTION

The Lab@Future project (the project full name being - 'School LABoratory anticipating FUTURE needs of European Youth') is a research and development project, funded by the European Union (EU) as part of the Information Society Technologies (IST) program.

The project investigates the means by which pedagogical insight and state-of-the-art technologies can be harnessed in the development of e-learning technological tools so as to facilitate and enhance innovative approaches to teaching and learning in European high schools. In order to achieve this remit, pedagogical research in the Lab@Future project is underpinned by learning theories that highlight the significance of social and cultural aspects of teaching and learning practices in context whilst recognizing the dynamic nature of tool use behavior.   Given this consideration, Lab@Future e-learning technological tools strive to support established ways of teaching and learning in focused contexts whilst nurturing emerging and innovative practices in teaching and learning methods. Lab@Future strives to achieve this by facilitating flexibility and exploration in tool use mechanisms when teaching and learning, therefore enabling the user to introduce new teaching methodologies and learning activities under a common communication and collaboration technological environment.

The main goal of the Lab@Future project is therefore, to research and develop a prototype system for supporting secondary school laboratory education. The overall rationale is that, both the pedagogical and technological effectiveness of the developed system will be evaluated at real educational sites i.e. school laboratories, educational venues e.g. museum and historical sites. In summary, key pedagogical and technological features integrated in the Lab@Future project include the following:

- E-learning and m-learning
- Open learning environments
- Human-computer interaction
- Constructivism, Activity Theory and Theory of Expansive Learning
- Communication and collaboration platforms for learning
- Mixed and augmented reality for learning
- Shared virtual learning environments
- Evaluation processes for learning

Teaching and learning experiments incorporated in the project's systems development and evaluation processes includes both laboratory and non-laboratory based teaching and learning for the disciplines of science (fluid dynamics), mathematics (geometry: developing spatial skills) and arts &

humanities (environmental awareness and history, including educational walks, visits and seminars).

2. THEORETICAL FRAMEWORK AND PEDAGOGICAL CONTEXT

The three major pedagogical theories that Lab@Future supports are *activity theory, the theory of expansive learning,* and *social constructivism.* The Lab@Future platform is focused on supporting novel pedagogical concepts and learning practices based on constructivism, combined with action oriented learning such as real-problem solving, collaborative learning, exploratory learning and interdisciplinary learning. When working with the outlined pedagogical theories, we recognize the fact that there are diversities and variations in emphasis when applied to learning research. Therefore, in order to achieve a workable compromise with regards to the various facets of these three theories, research in the Lab@Future project in capitalizing on exploiting the dialogical aspects of these theories so as to facilitate positive debate in the perception of teaching and learning from the viewpoint of these three theories.

The core commitment of a *constructivist* position in relation to learning is that, knowledge is not transmitted directly from one knower to another but is actively constructed or built up by the learner. Therefore, constructivism considers learning to be an active process in which learners "construct" their own knowledge by testing ideas and approaches based on their prior knowledge and experience, applying these to a new situation, and integrating the new knowledge gained with pre-existing intellectual constructs. Therefore, the social constructivist pedagogical stance is supported and enhanced by enabling the learner to engage in relevant activities that involve problem-solving and critical thinking.

Activity theory and *the theory of expansive learning* go a step further [3] in that 'subjects' or participants (e.g. students and teachers) in a learning activity consciously and unconsciously are engaged in dynamic learning goal or object formation. This entails that the outcome from a learning experience or activity cannot always be predicted because it will be influenced by several factors operating within the contextual environment or community in which teaching and learning takes place. This pedagogical stance therefore, emphasizes the fact that knowledge emerges as a result of disturbances or conflicts in learning activity, which results in the construction of novel practical activity systems and artefacts for use in real life contexts. Therefore, participants in a learning activity are essentially involved in constructing new:

- Learning activities
- Methods for teaching and learning
- Tools for exploring and interacting with learning objects.

In practice, this pedagogical stance requires that schools initiate partnerships involving all stakeholders or interested parties in the community in which teaching and learning occurs in order to uncover challenging contradictions and explore hybrid forms of teaching and learning activities in which both students and teachers become co-producers of knowledge or what must be learnt.

In order to apply theoretical perspectives drawn from both activity theory and the theory of expansive learning in a more practical sense, research in the Lab@Future project [4] used the activity triangle model also known as the activity system (see Figure 1) as a representational model to portray key theoretical aspects incorporated in the various elements of an activity system (see also Mwanza and Engeström, 2003). Elements of the activity system incorporate the various components and mediational relationships that exist within and amongst stakeholders in an activity system. Figure 1 shows the various components and mediational relationships of an activity system:
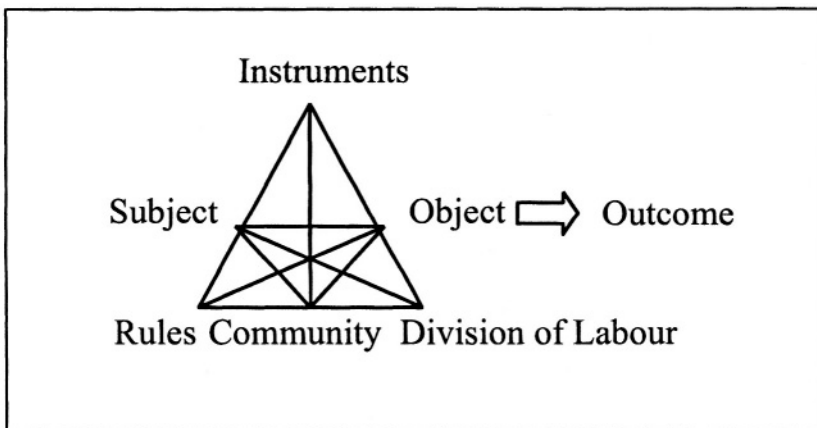
Figure 1. The activity system or activity triangle model (Engeström, 1987)

In order to map the theoretical perspectives described above onto systems design tasks, the activity system was used as a conceptual model for visualizing the various components and relationships in the targeted context of deployment during the requirements specification process. This was specifically associated with the abstraction of the division of labour through the conceptualization of existing roles within the teaching and learning

practices in the targeted schools and focused subject areas. During this design process, Lab@Future operationalised the activity triangle model in each focused subject area that was used as a test case for design purposes. Figure 2 shows an example of such operationalisation.
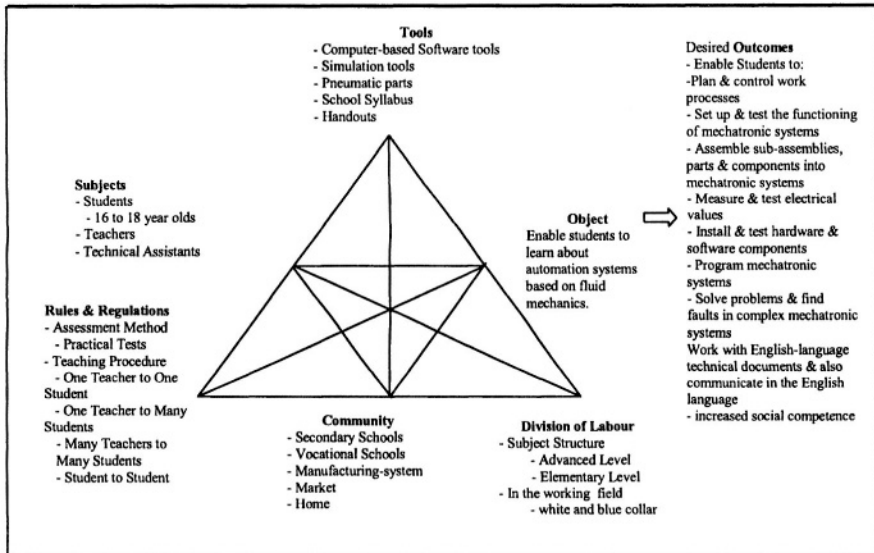
Figure 2. Activity System for Fluid Dynamics – a focused Science subject area in Germany

Figure 2 shows an activity triangular representation of components and mediational relationships that exist in the teaching and learning context of the Fluid Dynamics focused Science subject in Germany, which is one of the subjects and contexts being used as a test case during systems design. Fluid Dynamics as a science and practice subject proves to be especially suited for investigating consequences of the activity theoretical view on learning. The science of fluid dynamics with ever increasing theoretical models and refinements down to a quantum mechanical level, still have to be taught at a practical level for work in a factory. Many arising questions from production practice with pneumatic automation equipment (in a constructivist sense of disturbances or conflicts in learning and work activity resulting in the construction of novel mental models and practical activity systems and artefacts for use in real life contexts, see also Mwanza & Engeström, 2003) can be handled in a learning environment, where a bridge between school and factory, theory and practice is supported by adequate teaching methods and mixed reality tools.

3.   LAB@FUTURE DISTRIBUTED PLATFORM

3.1   Session definitions

A collaborative e-learning session (referred to later as a session) is constituted by a group of persons working collaboratively, handling experiment specific data, performing experiment specific applications and using a set of groupware tools as support of their work. The groupware tools provide the basic communication and collaboration services to the users registered in the session.

Two phases are defined within a session, respectively an *asynchronous* phase and a *synchronous* phase. When a session is created, it enters an asynchronous phase that is continuously active until the session is deleted by the administrator. In the asynchronous phase, the registered users are authorized to access independently (i.e. without any synchronization among them) the e-learning content of an experiment (for instance, access to experiment specific Web pages, access to experiment-specific virtual scenes) and to perform independently experiment specific applications. During the asynchronous phase, only asynchronous communication tools, like E-mail or news groups, are available to the users.

When a synchronous phase is running, it is the responsibility of each user to explicitly join/leave this synchronous phase. As a consequence, all the users, who have joined a synchronous phase of a session, are aware of each other, and may use different synchronous collaboration and communication tools to work together and implement a pedagogic scenario. It is important to notice that the asynchronous and synchronous phases are not mutually exclusive and may coexist. That is, when a synchronous phase starts, the asynchronous phase keeps active. In this way, users are always allowed to work asynchronously while taking also part in a synchronous activity.

A session is created, configured and deleted by an administrator. The *administrator* is also responsible to start and end a synchronous phase, either manually or by configuring a specific time schedule.

3.2   Architecture topology

The general architecture of the Lab@Future platform is presented in Figure 3. Main components of this architecture are:

A set of distributed user workstations interconnected to a WAN network; mobile user workstations, like wireless (802.11 and possibly GPRS) laptops and PDAs, will also be considered;

A set of distributed servers. Four types of servers are considered: the Lab@Future server, generic collaboration and communication servers (GCCS), multi-user virtual reality servers (MUS) and experiment specific servers (ESS).
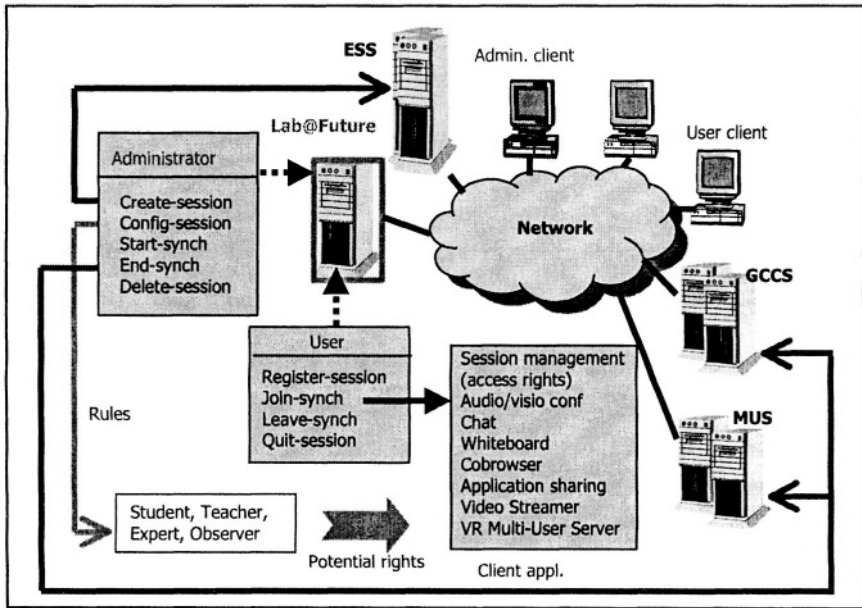
Figure 3. Lab@Future architecture topology

The set of client workstations for a collaborative session is made of, at most one administrator workstation, and one or more user workstations.

3.2.1   Lab@Future server

The Lab@Future server is a dedicated front end to access the platform. It provides a common Web interface for supporting the interactions of the administrator and the clients. Users may then access experiment specific data (e.g. Web pages, VRML scenes, Web applications), experiment specific applications and collaboration communication tools from a Web browser supporting the required plugins (like the Cortona VRML plugin of Parallel Graphics for interacting with a virtual scene), (http://www.parallelgraphics.com).

3.2.2   Generic collaboration and communication servers

The generic collaboration and communication servers (GCCS) contain and manage all the services required for informal communication among users during the synchronous phases of the sessions.

Three main collaboration and communication services are available during a session synchronous phase:
- Informal communication among users through audio video-conferencing (in a multicast setting) and chat;
- Document sharing through whiteboard and collaborative browsing;
- Video-based information sharing through application sharing and video streaming.

These services are implemented by a set of tools made available to the users during synchronous phases of the sessions. These tools belong to the PLATINE prototype environment developed by LAAS-CNRS.

3.2.3   Multi-user virtual reality servers

Some experiment-specific applications provide users with means to collaboratively interact on the same virtual scene. In order to allow the sharing of interactive virtual scenes, a multi-user virtual environment can be used [5].

Parallel Graphics Multi-user solution is a client-server based networking system that allows virtual worlds (described through VRML scenes) to be shared among different users, synchronizing movements and events from within the virtual environments over an IP network. It supports definition of 3D scenes with sophisticate shapes and animations. Then, users are able to move and explore by themselves the 3D scenes.

At the server side, the multi-user server (MUS) monitors user events in order to synchronize them. Accordingly, once a user changes something in a 3D world (like adding a new object), the MUS transmits the respective information to the rest of the clients.

Clients connect to the MUS with a Web-browser (including the Cortona VRML plug-in) or from a stand-alone application (often developed with the help of Parallel Graphics Cortona SDK). The Parallel Graphics Cortona engine allows users to interact with the 3D models in a one-sided way (local interactions) or synchronized with the other clients.

3.2.4   Experiment specific servers

Experiment specific servers (ESS) are dedicated data servers storing all the data and applications related to each particular experiment described in the next section. Through the ESS each experiment is integrated to the Lab@Future platform. In order to know how to start and stop an experiment and which experiments are available, the Lab@Future front-end queries the ESS by requesting a specific URL. The ESS returns an XML file that contains the needed information.

The XML based exchange file / protocol, used between the Lab@Future platform and experiment specific servers, is divided into two parts. The first one describes the ESS in general and the second describes the experiments that can run on this server. Information is provided in different languages. The Lab@Future front-end uses the best-suited version for display. By introducing the exchange protocol, extensibility and backward compatibility is guaranteed. The latter is fully supported by the Fluid Dynamics server.

3.3   Generic collaboration and communication tools

Collaboration and communication services are implemented by the PLATINE prototype (http://www.laas.fr/~vero/PLATINE_TEST/).

3.3.1   Informal communication among users

This service allows users to directly communicate the ones with the others through audio, video and text messages while the collaborative activity takes place.

The *multipoint video/audio conferencing tool* addresses the capture, compression, transmission, decompression and presentation of the multimedia streams. It is based on real or simulated *multicast* communication. The video and audio streams are based on the H.263 standard format to ensure compatibility with other current videoconference systems.

The *Chat* tool provides a textual communication service among the users. It can be used in parallel with the video/audio conferencing tool or as a backup informal communication service because it is more robust and less bandwidth consuming.

3.3.2   Document sharing

This service allows users to concurrently look at the same documents and possibly to edit them in a controlled way.

The *Shared whiteboard* tool provides a graphical document sharing service among the users. It reproduces the behavior of a classical whiteboard in a distributed way. The interface to the shared whiteboard is composed of a graphical window for each user. An authorized user loads images on the whiteboard (for example, JPEG, GIFF images) and writes annotations on them.

The *Collaborative browsing* tool allows several users to browse the Web synchronously, in such a way that a set of users follows the browsing activity of a privileged user [5]. It is an extension of traditional Web browsing activity where users are allowed to browse the Web together, in a synchronized way. This tool is a Java-based software environment where servers are responsible for tracking all browsing activity and dynamically defining user access rights. The collaborative browsing clients are synchronized Java applets.

3.3.3   Application sharing

The *Application sharing* tool provides users with a generic service for sharing any application. The application sharing tool periodically captures and samples the screen dumps of the shared application. They are displayed on a specific video window for each user. This window represents a remote view of the shared application. Through it, users can remote control the shared application.

3.4   Mobile clients

The Lab@Future platform is designed to take into account the new context created by the increased mobility of participants to e-learning sessions. Mobility opens new opportunities for e-learning but also adds constraints to the technical platform that supports the e-learning tools like for example limited bandwidth (in the case of low bandwidth wireless link, such as GPRS) and terminal limitations (smaller screen size of PDAs). Based on the rapid development of wireless technology, some of the central challenges of the Lab@Future project are to build useful systems that are well suited to small screens, require minimal or convenient user input, and adapt different data flow transfers to specific needs.

Anticipated benefits for the Lab@Future system from using a combination of wireless technology and PDA in e learning include:

Portability and mobility: Because of the small size and lightweight of wireless devices, students find them convenient to use and carry with them.

Flexibility: Students and educators can access information databases from almost anywhere. This includes while traveling or waiting in a queue.

Convenience: Whenever students need to contact teachers or urgently need information from the Internet, remote access is available to them. In particular, accessing the network using a PDA is very fast, compared with connecting the network using a modem.

Remote Accessibility: Students can add or update information remotely.

Ease of use: Using a PDA provides a larger screen than a mobile phone only. Also, it is convenient for user input.

Utility: A PDA provides some of the capabilities of a standard computer, such as processing and storing data.

The Lab@Future platform integrates a generic mechanism that allows dynamic adaptation of data and content to the constraints created by the mobility context. The Lab@Future adaptation framework consists of two main components: a basic middleware integrated in the platform as a content filtering proxy and a content presentation module (CPM), which is a set of specific modules that implement the specific adaptation functionality required by the application. The set of modules currently implemented is a set of custom tags, where each tag defines the way we want to display information. One tag per specific information object is created and for each tag a set of available actions (attributes of the tag) is defined. In this way, the CPM adapts html pages dynamically. The content adaptation is applied mainly to History mobile scenarios.

4.   EXPERIMENTS

The following sections describe the main functionality of the Lab@Future e-Learning application experiments, namely the Fluid Dynamics, the Mathematics and the Arts & Humanities Experiment.

4.1   Fluid Dynamics

The main functionality of the Fluid Dynamics experiment is the use of a Mixed Reality environment as an assistant tool for teaching Mechatronics [1]. The Toolkit is implemented as a distributed and collaborative Mixed Reality Web Service that integrates real and virtual, local and remote media under one common interface. With a special kind of coupling between the computer and real hardware, it is possible to build hybrid systems that are a mixture of real and virtual parts by using bidirectional connections for physical phenomena (air pressure and electricity).

Users have the possibility to learn the topic of Fluid Dynamics not only by theory but also in practice. They cannot only create virtual experiments but can connect them to real hardware. The Web Service gives also access to supporting material for each experiment. This material can be used for self-education and/or homework composition.

The Fluid Dynamics experiment specific platform suite consists of several modules that together build the deriveSERVER system. Each component of the system has its own dedicated task, e.g. simulation. A central module, which controls the communication and data flow between the different subsystems, is the Mixed Reality (MR) Server. It maintains the resources of running experiments. The user sees only the HTML based Front End, the Virtual Construction Kit (VCK).

The virtual model is interfaced to the real hardware process, utilizing diverse innovative devices such as the Hyperbond [2], an image recognition system, etc. With the help of video-streaming changes to the real hardware it can be observed at distant places. All software components are realized as specialized software agents that communicate via standard Internet protocols (TCP/IP). The network of communicating clients forms the overall (software) system.

Lab@Future experiment scenarios relevant to course topics in the subject area of fluid dynamics are: industrial safety circuit, swivel driver and comparison of real and virtual behavior of double acting cylinder.

The integration of Fluid Dynamics experiment specific platform into the Lab@Future collaborative platform is based on the HTTP/1.1 protocol that controls the Mixed Reality Web Service. Users are accessing the platform front-end in order to manage the Fluid Dynamics experiments. The Lab@Future server starts and stops experiments using the HTTP/1.1 protocol, while the Mixed Reality Web Service automatically starts and stops the specific applications for the actual experiment.

The learning objectives specified in the framework of the scenario design method of Fluid Dynamics are to enable students to:
- Learn about automation systems based on fluid mechanics.
- Plan & control work processes.
- Set up & test the functioning of mechatronic systems.
- Assemble sub-assemblies, parts & components into mechatronic systems.
- Measure & test electrical values.
- Install & test hardware & software components.
- Program mechatronic systems.
- Solve problems & find faults in complex mechatronic systems.
- Work with English-language technical documents & also communicate in the English language.

- Have some insight in automation theory and practice.
- Have some knowledge of the application domain (e.g. conveyor belts).
- Develop increased social competence.
- Develop increased reflexive perspective.
- Acquire visions of change.

4.2   Geometry

Within the scope of the Geometry Experiment a system called Construct3D is developed, which is a novel tool for teaching descriptive geometry using collaborative augmented reality. The system incorporates the following laboratory equipments used during teaching and learning:
- Personal computers (PCs) (these include laptops and desktop)
- Head -Mounted Displays (HMD) used for presenting the output of our system i.e. the real world augmented by the virtual elements generated by the application
- Trackers used for obtaining head and hand position and orientation information:
  - USB and Firewire webcam based tracking
  - Electromagnetic tracking
  - Computer-vision tracking
  - Ultrasonic/inertial tracking
  - Inertial tracker used for measuring head movements
- BARCO projection table
- P5 virtual glove

Each student has his or her own head-mounted display and interaction hardware, so they don't share these devices. This approach enables students to actively participate in the learning process. Since these displays are optical see-through HMDs, they can see each other and are able to communicate simply by speech as well allowing for natural, familiar and therefore effective means of exchanging information. In addition to the HMDs, there is also a provision for students to watch the 3D construction procedure passively on a large projection screen or computer screens. The large projection screen or computer screens can be "shared" or viewed by several users thereby enabling several students to passively participate in the learning activity.

One or more tracking servers are needed to process the data coming from the input devices of the users i.e. the pen and the panel of the Personal Interaction Panel that provides an Augmented Reality GUI (3D menus and pointer). This data is then sent to the machines needing it through the Local Area Network using multicast. The output images for each user can be rendered either on a central machine that processes the data coming from the

tracking server(s) and renders the images for the HMD or the monitor of the user, or each user has his/her own machine for the same tasks. The machines associated with one or more users run the Studierstube collaborative Augmented Reality platform, which uses the tracking data and user interaction information to render the graphical elements representing the user and the current application status, while the Construct3D application is running on top of Studierstube.

Geometry experiment learning scenarios within Lab@Future framework include: hybrid AR classroom, projection screen classroom, distributed hybrid classroom and remote collaboration.

All the machines – the input and output components - connect to the ESS of the Mathematics Experiment, which serves as the interface for the Lab@Future platform. More specifically, on the ESS of the Geometry Experiment the Studierstube collaborative augmented reality application is running. The Construct3D application is using and being run in the Studierstube framework. There can be multiple machines running Studierstube, in this case the Construct3D application runs in a distributed manner, the scene graph of the virtual scene and the updates to the scene are synchronized over the network.

The desired outcomes from teaching and learning geometry in Lab@Future environment are focused on enabling students to:

- Acquire an improved comprehension of complex spatial problems and relationships.
- Recognize structures & properties of geometric objects.
- Recognize basic geometric shapes in a bigger context.
- Create & modify objects by modeling and transforming them.
- Apply fundamental geometric knowledge in scientific & technical problems.
- Recognize & apply geometry as a language.
- Interpret & develop geometric representations.
- Learn correct use of specific tools in accordance with the problem to be solved.
- Learn to use special 2D and 3D educational software.
- Learn a programming language & use communication tools to describe and explain geometric objects & procedures.
- Acquire preciseness in expressing ideas through the use of drawing as a means of intercultural understanding.
- Prepare for the professional world by learning to be precise & organized.
- Capture, understand, analyze and model natural and artificial objects and models.

- Develop creativity.
- Improve fine motor skills.

4.3   Arts & Humanities

4.3.1   History

The main functionality of the History experiment is the use of Mobile Technologies as assistant tools during the visit of a high school classroom at an archeological monument. The experiment is implemented in the following way: the class of the moderator school visits a remote environment (outside the school premises). The moderator class students are holding mobile devices such as PDAs or Cell Phones enabled with WLAN access. Through these devices the students can communicate with the students of remote classrooms who are sitting in front of networked desktop computers in their classroom. The PDAs and desktop computers also allow access to supporting material residing on web servers, over the Internet. Finally the mobile devices could also include a digital camera for taking pictures at the remote site to be shared with the remote students, or used later for homework composition.

Lab@Future experiment scenarios that are relevant to history are: comparing the real monument with its virtual representation on the PDA, looking for information in relevant websites through their PDA device and using this information in order to enrich the learning impact of the educational visit, communicating and exchanging information through the mobile devices and using PDAs and GRS Mobiles phones when studying classical art.

The ESS of the History Experiment serves as the interface for the Lab@Future platform. As mentioned earlier in the paper, History experiment also uses the Lab@Future adaptation framework to overtake the various constraints induced by mobile contexts.

4.3.2   Environmental awareness

The main functionality of the experiment is to enhance the learning effectiveness on the field and in the laboratory by making use of as much relevant and necessary information as needed concerning environment.

Learning experiments relevant to environmental awareness consist of scenarios involving the simulation of the environmental pollution in freshwater lakes, i.e. modeling a healthy lake and then studying what happens if pollution takes place. These are exploited in the following

scenarios: populating the lake with plants and animals, testing for animals and plants "survival" parameters, checking the degree of biological relevance and testing the impact of environmental factors.

The experiment specific tools, applications and data depend on the technology level of the school class performing work. The environmental awareness experiments are designed so that they can be performed with minimal equipment needed for Lab@Future platform. This experiment specific platform integrates with the Lab@Future collaborative platform with the use of Wireless LAN or GPRS.

The major learning objective of the environmental awareness experiment is to enable students to acquire awareness and practical skills for analyzing factual data about the purity of the environment.

5.   CONCLUSIONS

Lab@Future defines a generic - universal "mixed and augmented reality" platform energizing mobile and wireless information interaction and addressing issues of the constructivist theory of learning, in combination and dialogue with activity theory, especially the theory of expansive learning. It provides a constructivist and expansive framework that introduces innovative features to e-learning, which can serve successfully as a common teaching environment in schools throughout Europe.

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VIRTUAL LABORATORIES IN EDUCATION

A cheap way for schools to obtain laboratories for all courses, by using the Computer Laboratory[1]

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Abstract: Practical experience is an important component of the educational process. However, the time and economical resources often required for the setting up and construction of scientific laboratories is outside the scope of many institutions. A solution to this problem could be found in the adaptation of the Virtual Reality technology, which could allow the creation of Virtual Laboratories, which will simulate the processes and actions that could take place in real laboratories. In particular, this paper, based on the expertise and motivation gained by the VirRAD-IST project, proposes and describes such an educational virtual laboratory, which aims to meet the requirements of a real laboratory and furthermore to support communication and collaboration services. We propose a web-based system, which allows users to perform experiments on educational fields, such as Physics or Chemistry in 3D multi-user worlds where users are represented by avatars and they are offered a wide range of communication and collaboration services in order to simulate efficiently a real learning experimental process.

Key words: Distance learning, Virtual reality, Multi-user virtual environments, Virtual Laboratories, Educational Virtual Environments.

1. INTRODUCTION

The wide expansion of the World Wide Web (WWW) and the maturation of the Internet along with the step-up of both the network infrastructure and

the electronic communication formed all the necessary preconditions for adopting this powerful means of communication for accessional purposes.

Regarding the technological field, Virtual Reality (VR) technology has been widely proposed and recognized as a major technological advance for supporting life-long education to individuals along with a flexible workforce. One of the unique capabilities of the VR technology is the successful translation of abstract concepts into visualized events along with the possibility of the users' interaction with them, that in real life could be limited due to distance, time and safety factors[1].

The extended functionalities that a Virtual Environment could provide, in combination to the increasing research interest for distance learning led to the creation of a wide range of applications that adopt Virtual Reality technology in order to support the learning process and such forming the so called Educational Virtual Environments. However, apart from the technological aspects that Virtual Reality embraces, the term "educational" posts a number of issues, e.g. on the access of the learning content as well as on the educational model that should be used for the optimized realization of the learning process. One of the most evolving trends to this direction is experimental learning or "learning by experience" where users are encountered as actors and not as passive receivers of the information provided. Experimental learning involves a high degree of interactivity of the users both with other users as well as with the objects available in the Virtual Environment[3]. A case of such an environment is the Virtual Radiopharmacy Laboratory, created on the framework of the VirRAD IST project, which will be presented in a following section. Furthermore, another example of a distributed virtual reality environment for simulation-based learning is C-VISions. C-VISions is a research project, which focuses on the implementation of a multi-user 3D environment for educational purposes. In order the learning process to be realized, users are represented by avatars in a 3D environment[1].

The evolution noticed in Information and Communication Technologies has also affected Greece, both in the industrial as well as in the educational field. In regard to the educational field, it should be mentioned that the last decade the majority of secondary schools have been equipped with computer laboratories in order the students to become familiar with the information society and the new technologies. In addition, a network for the internal connection of all schools has been established, allowing the communication and collaboration of individuals in the field of secondary education. However, the educational system has not taken full advantage of additional capabilities that the school computer laboratories could present. Therefore, this paper emphasizes on the description of a platform that Greek Secondary

Schools could adopt in order trainees to meet "Learning by experience" and collaboration, over the Greek School Network[5].

The remainder of this paper is structured as follows. In section 2 fundamental issues of Virtual Laboratories are apposed and their role in education is underlined. In section 3, a Virtual Laboratory called Virtual Radiopharmacy Laboratory is presented. Section 4 is dedicated to a proposed scheme that could allow the creation of Virtual Laboratories in Greek secondary schools. Following this, the functionality provided by these Virtual Laboratories is presented. Finally, some concluding remarks are briefly described.

2. VIRTUAL LABORATORIES IN EDUCATION

Practical experience is an important component of the educational process. However, the time and economical resources required for the setting up and construction of scientific laboratories is outside the scope of many institutions. A solution to the above problem could be found in the adaptation of Virtual Laboratories, which could be proven as an important educational tool that deals with the lack of practical experience in education[2].

Among the many benefits of virtual laboratories, the following are particularly important:
1. Resource sharing becomes a reality, improving the utilization of costly equipment.
2. Access to educational and research material is facilitated for both students and professionals.
3. Scientific investigation standards are established in areas where practical experimentation is a required part of research.
4. Reduction in travel time leads to productivity enhancements

A virtual laboratory that uses VR technology to support e-learning is the Virtual Radiopharmacy Laboratory which is described in the following section.

2.1 The Virtual Radiopharmacy Laboratory

The Virtual Radiopharmacy Laboratory is a 3D simulation of a real radiopharmacy laboratory where learners, represented by 3D avatars, can experiment on radiopharmacy equipment by carrying out specific learning scenarios. This laboratory has been implemented in the framework of the VirRAD European project, which has as main goal to support the Radiopharmacists' community worldwide.

One of the most powerful characteristics of the Virtual Radiopharmacy Laboratory is that it aims to support both RBL and collaborative e-learning, by being accessed in two different modes: the study and the multi-user mode.

In the study mode, as it is shown in Fig. 1, the user can interact with the environment without the presence of other users. His/her help is an intelligent learner modeling that provides assistance to the user according to the dynamic actions that s/he performs on the available equipment of the virtual space.

Figure 1. Virtual Radiopharmacy Laboratory: The study mode

The multi-user mode of the Virtual Radiopharmacy Laboratory, as it is shown in Fig. 2, provides a virtual environment that allows learners to interact with other learners / mentors or with the equipment of the laboratory, exactly as it would happen in a real radiopharmacy laboratory.

Figure 2. Virtual Radiopharmacy Laboratory: The multi-user mode.

Thus, through his/her 3D representation, every participant has the ability to communicate, discuss and cooperate with other participants and as a team perform actions in the laboratory, having in mind that these actions must be in accordance with the specific learning scenario[1].

3. VIRTUAL LABORATORIES IN GREEK SECONDARY SCHOOLS

The last years the majority of Greek secondary schools have been equipped with computer laboratories so that learners can become familiar with the information society and the new technologies that arise. In addition a network, the Greek School Network, has been established for connecting the secondary schools to the Internet and for providing educational network services. In particular, the computer laboratories are mainly used for the tuition of the Informatics course, where learners are introduced to some primary programming and algorithms as well as to the use of the Internet[5].

However, the educational system has not taken full advantage of additional enhanced abilities that the school computer laboratories and the new technologies could provide. Therefore, the approach of this paper is that by combining the school computer laboratory, the experience that the students gain from the teaching of the information science course and the powerful capabilities of Virtual Reality technology there could be developed Virtual Laboratories for various lessons such as Physics and Chemistry.

The benefits that the adaptation of Networked Virtual Environments could present for the learning process plead to this direction. In particular, a networked virtual environment could sub serve the learning process in two ways:

1. Creation of Virtual Courses: Each trainee is represented by a 3D entity with human-like characteristics and through this representation s/he can collaborate with the other trainees as well as attend the tutor during the session of the Virtual Course.
2. Simulation of school laboratories: In many cases the creation of real laboratories for special kind of courses is limited due to practical or economical constraints.

The Virtual Laboratories proposed in this paper involve the design, development and realization of pre-determined experiments that will simulate phenomena and processes that could take place in real-world situations. The above-mentioned laboratories could act either as complement of the existing school laboratories or as independent laboratories, especially for courses where the real laboratories cannot be developed for practical reasons.

The anticipated Virtual Laboratories have as main target to form Educational Virtual Environments in order to provide to the Greek secondary schools additional practical educational material and experiences in fields of tuition, such as Physics. In this case and in order to achieve the above goal the Virtual Laboratory designed will simulate a set of Physics experiments that could take place in a real Physics laboratory along with special experiments that could not be easily executed in real laboratories.

Finally, one of the most important elements of this proposal is the scalability that the approach maintains through the adaptation of open source technologies. In particular, both the platform that supports the Virtual Environments and the simulators of the experiments can be developed with open source technologies, as VRML. Furthermore, the final platform that will allow the creation and will support the Virtual Laboratories can be provided as open source application, free of charges and limitations that are commonly related to proprietary technologies.

3.1   Proposed Architecture

This section is dedicated to the description of the proposed architecture of the system that will support the Virtual Laboratories in Greek Secondary Schools. The architecture refers to the logical view of the static structure in terms of its components, their interconnections, as well as the interfaces and operations offered by these components.

The system architecture, which is presented in Fig. 3, is based on the following components for providing the needed functionality: a database, the platform that supports multi-user environments and simulations, a web server and the Greek School Network which connects the system with the participants' clients. These components are described below in detail.

The database of the system stores the information about students such as their name and password, their profiles, their role in the system that could be either tutor or learner, as well as the avatar they have selected for their representation in the Virtual Environment.

The Networked Virtual Environment (NVE) server, which is the multi-user platform, provides and maintains a consistent view of the Virtual Laboratories and of the shared objects in it. In addition it provides communication and collaboration tools such as text and audio chat, application sharing, etc in order to simulate as more realistic as possible the interactions of the participants.

As it is depicted in Fig. 3 the users can access the system using a web browser. The web server can be used in order to host the 3D training areas where simulations take place, the client-side files of the Virtual Laboratories and the avatars of the users. Furthermore, the web server stores and executes

the scripts in order to obtain and manipulate the users' data from the database.

The connection of the client's browser and the platform is materialized over the Greek School Network, which is an advanced educational network that connects all school computer laboratories and creates an educational intranet. This national infrastructure provides and supports advanced telematics services to the school communities. The design model and the operational specifications of the GSN are based on the TCP/IP protocol.
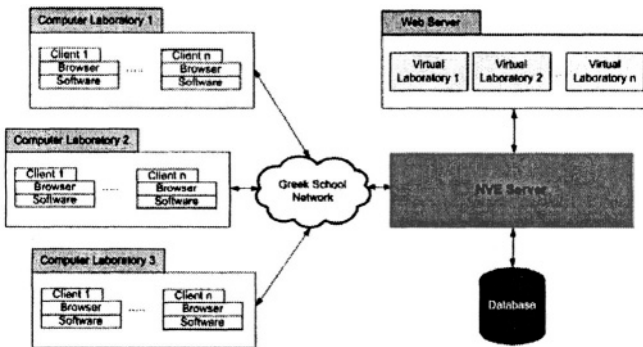
Figure 3. Proposed Architecture

As mentioned above, the systems architecture constitutes a simple structure, which, however, could allow and support efficiently the basic functionality that the platform is intended to offer.

3.2   Basic Functionality

The main goal of an Educational Virtual Laboratory is to provide all the simulations, tools, applications and conditions necessary, which will constitute an efficient space where experimentation, communication and collaboration can be used for the maintenance and exchange of rich knowledge[3]. Thus, the virtual environment that will host the laboratories, trying to simulate the learning process from its very beginning until its completion, should, first of all, include all the necessary functionality to its users so as to simulate the real processes as more realistic as possible. The functionality diagram of a Virtual Laboratory is displayed in Fig. 4.

The Virtual Laboratories comprise Virtual Worlds where users are represented by 3D human like avatars and have the ability to navigate in the environment, conduct experiments by interacting with the simulated equipment and collaborate by interacting and communicating with the other participants. Therefore, in a Virtual Laboratory where Physics is selected, for example as the application field, tutors will be provided with the ability to

teach the each time selected course while the learners will have the ability to perform experiments in fields such as electricity, magnetism, mechanics and other fields of Physics without the necessary existence of conventional accoutrements.
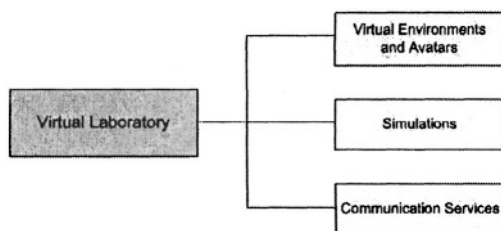

Figure 4. Functionality diagram of a Virtual Laboratory

For the achievement of the purpose that a platform like this one could have, the functionality that will be provided by the Virtual Laboratory can vary in respect to the kind of the laboratory that will be simulated[4]. However, in all cases the platform should support the following:

a) Creation of Virtual Laboratories, where the placement and manipulation of objects that will be used to the experiments will be possible.

b) Representation of the users, both tutors and learners through human like entities, called avatars.

c) Creation of dynamic characteristics and physical attributes to the objects as gravity, reflection, etc.

d) Definition of the possible ways of communication.

The aforementioned functionality can supply a wide range of the requirements that the learning process could have in a real laboratory. Such an environment could support learning by experience even in cases that either the lack of resources for the creation of real laboratories or the deficiency of available spaces constrain the learning process.

The benefits of such an approach are the following:

1. Significantly reduced cost for the composition of a school laboratory, as it only requires addition of the necessary software to the existing Informatics Laboratory.

2. Mistakes of both tutors and learners cannot be proven catastrophic for both the lab and the participants' health.

3. The interaction with the virtual environment motives the users, especially the learners more in regard to the real process.

4. This idea allows the simulation of Laboratories that could only exist in computers and could not be realized in real conditions.

As extracted from the above, the first criterion for the design and the development of a virtual laboratory is the selection of the field that will be

adopted for the simulation processes. This field will define the procedures that should be simulated as well as the learning process that will lead to the achievement of knowledge and experience. The next step is to provide to the end users all necessary services so as to reach a high sense of realism.

4.   CONCLUSIONS

As the Internet is turning into a truly multiservice network with a steady increase in bandwidth and decrease in response time, the environment becomes more suitable for implementations such as virtual laboratories using VR technology.

Traditionally, the laboratory has been an integral component of education for relating fundamental concepts to basic real-world phenomena. Conducted largely within the confines of the lecture-classroom format, the laboratory involves the use of largely pre-determined experiments that simulate basic phenomena found in real-world situations. Unfortunately, the lecture-classroom-laboratory system has its flaws or demanding requirements: time-space dislocations of what is taught, what is explained and learned, and what is practiced and internalized, as well as the need for large amounts of space and complicated logistics to create and maintain an appropriate learning environment.

However, the role of conventional laboratories for training and understanding educational problems is presently being challenged. The advances made by Information Technology has led to some learning processes being replicated to varying degrees in the form of courseware available through the Internet, thereby overcoming some limitations of the traditional lecture-classroom-laboratory system.

Virtual laboratories seem to be preferable to real laboratories in the following cases:
1. The learning procedure through real laboratories puts students life in jeopardy.
2. Some experiments cannot be performed due to time constrains or hazards.
3. The cost in order to construct or to preserve a real laboratory is forbidden.
4. There are experiments that can be simulated only in computers.

Virtual Reality provides a friendly representation of the provided information, interaction with the system, which does not require advanced knowledge of the computers technology and reduced cost compared to other technologies. In addition, one of the most important aspects of this proposal is the fact that the development of Virtual Laboratories can be fully

supported by the existing Computer Laboratories, without the need of additional investments and infrastructure.

5.   FUTURE WORK

The step that follows the design of the system is to proceed with the implementation of the Virtual Laboratory. Firstly, there should be a decision on the educational field that is going to be simulated by the virtual laboratory, for example the Physics or Chemistry Laboratory.

When this field is defined, the equipment and the actions that will be simulated should be defined so as the models and the simulations to be designed and implemented respectively.

Following the gathering of the necessary information is the actual implementation of the multi-user platform that will support the simulations as well as the communication and collaboration services.

The next step is to conduct a user evaluation by setting up the platform in two selected Secondary Schools so as to get feedback on the correctness of the scenarios simulated as well as on the usability and friendliness of the represented information.

Finally, the platform will be provided to all Greek Secondary Schools as Open Source application, which will run over the already existing Greek School Network.

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Session 2

E-Learning Evaluation and Usability

CLUSTERING STUDENTS TO HELP EVALUATE LEARNING

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Abstract   In this paper we show how clustering techniques can be applied to student answers generated from a web-based tutoring tool. In particular we are interested in extracting clusters of students based on the mistakes they made using the tool, with the aim of obtaining pedagogically relevant information and providing this feedback to the teacher. The data we used comes from the Logic-ITA, a web-based tutoring tool to practice formal proofs currently in use in the School of Information Technologies at the University of Sydney.

Keywords: Tutoring systems, Data Mining, Clustering.

Introduction

Distance education, flexible education as well as increasing number of students in some fields make all use of new technologies to enhance learning. On-line tutoring tools belong to these new technologies. Such tutoring systems allow for storing complete student answers, including mistakes, in a database. It becomes possible to mine this database to extract pedagogically relevant information and provide feedback to the teacher.

Towards this end, Data Mining forms the basis for finding new patterns in data. When data is stored in a database or data warehouse, some relational associations of data elements are defined by the database designer. However, it may well be that the data that has been stored contains more information,

more relationships than what has been intentionally put while designing the database. The aim of Data Mining is to find those hidden patterns. Data Mining uses various techniques and algorithms that are quite different in nature. These comprise simple counting and visualization techniques including histograms, as well as more complex algorithms such as clustering, association rules, decision trees, neural networks etc [4].

Data Mining has been used mainly in business with success but also failure stories. There are two pitfalls to avoid. Not discovering existing hidden patterns, or discovering false hidden patterns. Therefore, when applying Data Mining algorithms, it is essential to select carefully the data, to tune up the algorithms carefully and to interpret the results carefully. Naturally this also applies to mining data collected from learning systems.

In this paper, we report on our experiment using clustering on data collected from the Logic-ITA, [1, 5], a web-based Intelligent Teaching Assistant system that is currently used within the School of Information Technologies, University of Sydney. It allows students to practice formal proofs in propositional logic whilst receiving feedback and also keeps the lecturer informed about the progress the class is making and problems encountered. The system embeds the Logic Tutor, a web-based intelligent tutoring system destined to the students, along with tools dedicated to the teacher for managing teaching configuration settings and material as well as for collecting and analysing data.

The contribution of this paper is to show a simple yet relevant way of using clustering, based on students homework as opposed to logs, yielding two homogeneous groups of students that suggest to teachers two different kinds of learners.

The aim of applying clustering to data from the Logic-ITA was to characterize students with difficulties. Clustering algorithms rest on a distance between individuals (or records). In our case, the choice of a distance was not obvious at all because of the heterogeneous way the tool is used. Students practice with the tool at their own pace and with different frequency of usage: Some students use it a lot, on a big variety of exercises, and others make little use of it. There is no fixed set of exercises that can be used to compare students with each others.

Mining data from learning systems begins to receive attention from the research community. In the context of web-based systems, web logs are mined to search for interesting learning-related patterns of usage [10]. Other researchers make use of genetic algorithms and association rules for finding information about students in an adaptive hypermedia system [7]. Association rules have been applied to our system, the Logic-ITA, to extract mistakes often made together by students [6]. Clustering techniques are argued to be useful to find student sequences through learning resources in [8]. The closest work to the work presented in this paper is [3]. They report on clustering students using, as

data, not only students' homeworks, as we do, but also students' interactions with the learning system. The clusters they have obtained were sensible and easy to interpret for about half of the population only.

The paper is organized as follows. Section 2 introduces briefly the Logic-ITA, in order for the reader to undertsand the nature of an exercise and possible mistakes using the system. Section 3 presents clustering, how we haved used it on our data and the results. Section 4 concludes the paper and discusses future work.

1.1 The Logic-ITA

The Logic-ITA is an intelligent teaching assistant system for the domain of formal proofs in propositional logic containing components for the students and for the teacher. The Logic Tutor, the component dedicated to students, provides an environment where students can practice formal proofs of logic at their own discretion, receiving step-by-step, contextualised feedback. They can choose to create new exercises, select exercises in the exercise database, or ask the system for one adapted to their needs. The system stores, for each student, every step entered by the student, along with any mistake they may have made. We will describe shortly the nature of an exercise.

Then the Logic-ITA collates all this information into a database that the teacher can query, in order to retrieve information about the way students accomplished the exercises and re-adjust the content and material of the teaching.

We will not describe in great details the whole system (the reader can refer to [5]) but we need to explain how some of this data is generated to make the following sections clearer.

Description of an exercise

Exercises start with a given set of premises, i.e. a set of well-formed formulae (wff) of propositional logic, and exactly one wff, the conclusion. The task then consists of deriving the conclusion from the premises, step-by-step, using laws of equivalence and rules of inference (we will refer to both of these as rules for the rest of this paper). Figure 1 shows a screen shot of the interface. Here the student was given the first two lines (lines 0 and 1) and the conclusion *C*. For each step, the student must fill out a new line, entered at the bottom of the screen. The student needs to do the following:
- enter a formula in the *Formula* section,
- choose, from a pop-up menu, the rule used to derive this formula from one or more previous line(s) *(Rules),*
- the references of those previous lines *(Line References)* and
- the premises the formula relies on *(Premises).*

File View Question Help

Premise References	Line Number	Formula	Rule	Line References
{0}	0	(A| (B & C))	Premise (P)	{}
{1}	1	(A -> C)	Premise (P)	{}
{2}	2	~C	Premise (P)	{}
{1, 2}	3	~A	Modus Tollens (M.T)	{1, 2}
{0, 1, 2}	4	(B & C)	Disjunctive Syllogism	{0, 3}
{0, 1, 2}	5	(C & B)	And Commutation	{4}
{0, 1, 2}	6	C	Simplification (Simp)	{5}
{0, 1, 2}	7	(C & ~C)	Conjunction (Conj)	{6, 2}

Question

Mistake History

Statistics

Premises	Formula	Rules	Line References
0,1	C	Conditional Proof (C.P) ▼	2,7

Add Line

Figure 1.   Screenshot during an exercise.

For example in Figure 1, the student is currently deriving the formula *C,* using the rule *Indirect Proof* and the formulae of lines 2 and 7. Because lines 2 and 7 rely respectively on premises 2 and 0,1,2 (as can be seen in the first column of the screen) and *Indirect proof* removes the premise 2, the line entered therefore relies on premises 0,1. It is actually the last step of this exercise, deriving the conclusion.

There are often many ways to prove an argument valid. The important aspect is that the reasoning must be sound. The actual path followed is not important, as long as each step is valid. Hence students have total freedom in the reasoning they choose to follow.

Exercises come from various sources. Some belong to the core database of the system: they are assigned a difficulty level and are accessible by all the students. Others are created by the system and are downloadable locally. Students can also create exercises. Locally created exercises as well as exercises created by students all have a unique exercise identifier. This means that identical exercises (either created by the system for different students or created by different students) may appear as different when they are stored in the LT-Analyser since they have different identifiers. Furthermore, local exercises as well as exercises created by students have an unknown difficulty level. As a consequence, analysing how students managed a particular exercise only makes sense with exercises belonging to the central database of exercises, with a central and unique identifier.

Mistakes

At each step, the system checks the validity of the data entered by the student. There are different types of mistakes, and, each of them is labelled with a meaningful title for the teacher. Some are generic: *Wrong reference lines,* and others are more specific *Simplification before Commutation.* In addition, the rule specified at the time of the mistake is also recorded and linked to the mistake.

This means that there are two important aspects in a mistake: its type (for example *Wrong reference lines*) and the rule involved (for example *Modus Ponens*).

The student models, all centralized in one place on the server, contains the history of all exercises attempted and mistakes made. The LT-Analyser regularly scans all the student models and builds a database collating all that information. The database contains various tables. The table that is here most interesting for us is the table *Mistake* which provides an index to mistakes for each question attempted by each students. Each line (or record) of this table contains student's login *(login),* exercise id *(qId),* type of mistake made *(mistake),* rule involved *(rule)* and date. When part of the date is missing, the exercise is unfinished. The database is in Microsoft Access and is connected to Microsoft Excel. The teacher has then the choice of querying the database with either software and visualise graphics in MS Excel. The aim of the LT-Analyser is to provide information to the teacher about the class, so that s/he can adapt his/her teacher accordingly, or be aware of individuals needing assistance. Currently, we are extending the LT-Analyser with Data Mining facilities.

1.2   Clustering students

One need, for teachers, is to cluster students into homogeneous groups with respect to their abilities concerning the course material. In particular, it is important to be aware of groups with difficulties to take proper action. Two well known methods for clustering a population are k-means clustering and hierarchical clustering. In this section we present these methods, how we have used them on student answers from Logic-ITA and discuss the results.

K-means and hierarchical clustering

Both k-means and hierarchical clustering rest on a distance concept between individuals. Distance is taken here almost in its mathematical meaning with $d(x,x) = 0$, $d(x,y) = d(y,x)$ and $d(x,y) \leq d(x,z) + d(z,y)$ for any individuals x, y and z. It is the user's responsibility to fix a distance for the population before performing a clustering. Most of the time, changing the distance changes the resulting clustering.

K-means clustering partitions the populations into **k-classes** where **k** is fixed in advance by the user. The algorithm works as follows.

k-means clustering algorithm.
 Select a population and a distance between individuals.
 Choose k random individuals as initial centers.
 Repeat
   For each individual,
     Calculate its distance with all the centers and
       put it in the cluster with the nearest center.
     Calculate new centers by taking the mean of each cluster.
   Till there is no more change in the clusters.

Hierarchical clustering does not ask for an initial number of clusters. Rather, classification is stopped when the distance between two groups is too large and no longer guarantees the homogeneity of the individuals grouped together. There are several ways to measure the distance between two groups. One common way is to calculate the distance between any two pairs and take the average. The algorithm works as follows.

Hierarchical clustering algorithm.
 Select a population and a distance between individuals.
 Each individual forms an initial group.
 Calculate distances between all groups to form a distance matrix.
 While there is more than one group and distance between two
   nearest groups is below a given threshold
     Repeat
       Cluster these two nearest groups into one.
       Recalculate distances between all other groups
         and this newly formed group.

The advantage of hierarchical clustering over **k-means** clustering is that its result is unbiaised by initial parameters. Indeed, the random choice of initial centers as well as a given number of clusters influence the result for **k-means** clustering. However, the complexity of **k-means** clustering is linear, while hierarchical clustering is polynomial. Therefore many Data Mining softwares offer a combination of both, known as *two-steps* clustering. First individuals are grouped according to **k-means** clustering, where **k** is chosen to be far larger that the number of expected clusters. Its effect is to reduce the original size of the population in linear time in something which is manageable for hierarchical clustering. Then, hierarchical clustering is performed on these **k** clusters to yield final clusters.

Use of the clustering with Logic-ITA

We have chosen to perform a *two-steps* clustering on the data collected from the Logic-ITA using the Data Mining software Clementine® [9].

The first thing to do is to select the population. Our aim was to cluster students who seemed to have difficulties. Therefore, we have taken the table *mistake* and selected only the lines corresponding to non-finished exercises. Indeed, finishing an exercise means being able to complete a full proof and, thus, correct all the mistakes made on the way. From the initial population of 149 students having made mistakes, we went down to 60 students.

The second thing to do is to fix a distance between two individuals. This is no trivial task. Indeed, students have not attempted the same exercises, nor the same number of exercises. Furthermore, a large numer of exercises attempted by students does not come from the database of exercises provided by the teacher. Indeed, students are free to type in their own exercises, or to try exercises from the exercise generator. These latter exercises have a unique identifier and an unknown level of difficulty. Thus, exercises attempted by students can hardly be compared by level. After various attempts, what worked best was the simplest one could do: count all mistakes made per student, which gives exactly one number and use the difference in absolute value as a distance between two students (which is equivalent in that case to the Euclidean distance): let $CountMistake_x$ and $CountMistake_y$ be the total number of mistakes made by student x and y respectively. We get $d(x,y) = |CountMistake_x - CountMistake_y|$. Running the algorithm led to two clusters:

- *cluster_1* containing 21 records (in our case students), average = 39.1, standard deviation = 15.6.

- *cluster_2* containing 39 records, average = 7.5, standard deviation = 4.7.

Thus students from *cluster_1* made a lot more mistakes than students from *cluster_2*.

Apart from their number of mistakes, is there any other way to qualify these two groups and interpret the result? To answer this question, we have used the graphical visualization of relations offered by Clementine® between clusters, rules and mistakes. To build the relationship, the number of occurrences of any two items in a line of the table is counted. For example, counter(*cluster_1*, *Modus Ponens*) is the total number of lines in the table where some student of *cluster_1* made a mistake with the rule *Modus Ponens*. Similarly, counter(*cluster_1*, *Wrong rule used*) is the total number of lines in the table where some student of *cluster_1* made a mistake called *Wrong rule used*. This relation is displayed graphically as a graph where the nodes are the different items: *cluster_1, cluster_2,* all rules (like *Modus Ponens,* etc...) and
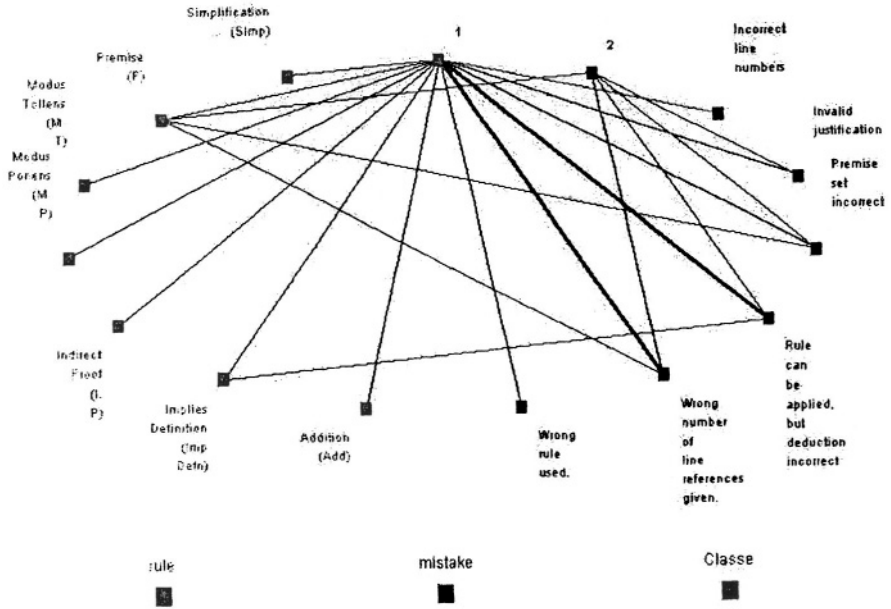
Figure 2.   The relations between clusters, rules and mistakes with a threshold of 20 from Clementine®.

all mistakes (like *Wrong rule used* etc...). There is an edge between any two nodes if their counter is bigger than some number. The thickness of an edge is proportional to the counter value. In Figure 2 we show the graph where the threshold value for counters is 20 (a smaller value like 5 gives a spinweb!).

First, confirming our earlier results [6], this graph puts in evidence very common mistakes that belong to the core learning of formal proofs and that are made by almost all students. These mistakes are *Premise set incorrect, Rule can be applied, but deduction incorrect* and *Wrong number of line refer- ences given.* The first mistake indicates that the premises given by the student are wrong, the second one indicates that the formula given by the student is wrong and the third one indicates that the line numbers given by the student are wrong. It is interesting to note that two mistakes appear only with students from *cluster_1*. These are *Incorrect line numbers* and *Wrong rule used.* The mistake *Incorrect line numbers* indicates that the student provided only 1 line number when 2 where expected with the rule used, or vice-versa. The mistake *Wrong rule used* indicates that the rule cannot be applied to the lines given by the student. This graph shows also clearly that students of *cluster_1* have tried a lot more rules.

To go further in the comparison, we have selected the exercise that has been most often attempted by students, which happened to be the exercise with *qid* 1003. We have used the same clustering method as before selecting only students who have attempted that exercise without completing it. This gave 17 students. *Two-steps* clustering gives now four clusters.

- *c_1* containing 3 records, average = 29.7, standard deviation = 1.9

- *c_2* containing 6 records, average = 3.3, standard deviation = 1.5

- *c_3* containing 5 records, average = 8.6, standard deviation = 1.6

- *c_4* containing 3 records, average = 18.0, standard deviation = 2.2

Is this clustering consistent with the one obtained above? If one thinks of *c_2* and *c_3* as corresponding to *cluster_2* and *c_1* and *c_4* corresponding to *cluster_1,* then the two clusterings are quite coherent. All students, except for 1, belonging to *c_1* or *c_4* also belong to *cluster_1,* while almost all students belonging to *c_2* or *c_3* also belong to *cluster_2*. There are altogether 4 mismatches. One belongs to *c_4* and *cluster_2*. He made 16 mistakes on that exercise. Others belong to *c_2* or *c_3* and *cluster_1*. They have made 2 to 6 mistakes on that particular exercise, but many mistakes on the other exercises that they have attempted. The graph relationship for these four clusters is shown in Figure 3 and bears similarities with the previous one.

A further question is: where are the students who have not finished any exercise? Altogether 9 students have not been able to complete any exercise and made mistakes in the exercises they have attempted. A third of them is in in *cluster_1* and the rest is in *cluster_2*.

Discussion

From a teacher point of view, how can we interpret the clusters we have obtained? What do they suggest about the student learning? As a result of the bigger variety of rules used and mistakes made, students of *cluster_1* appear as if they would try out the tool, more than they use it thoughtfully to solve exercises. Students of *cluster_2* appear as being lost or as giving up quickly. We have performed a k-means clustering with the same students using TADA-Ed, a prototype research Data Mining tool [2]. Our tool has a point view module that allows to visualize *login* against *rule*. The resulting graph has vertical lines that shows clearly students trying one rule after the other from the menu (apparently relying heavily on a "guess and test" strategy). This agrees with our interpretation for *cluster_1*.

Analysing the mistakes made in unfinished exercises and finding these two clusters of students is very useful for the teacher as they give an insight on the reasons for the mistakes. The remedial actions a teacher can take are very
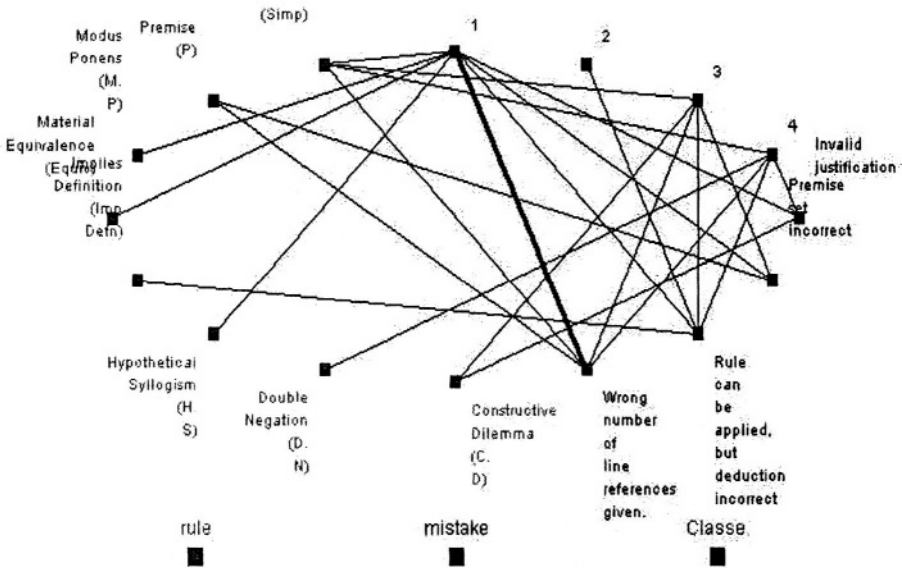
Figure 3.   The relations between clusters, rules and mistakes for students not completing question 1003 with a threshold of 4 from Clementine®.

different depending on the efforts made by the students and the reasons for their failures. For those who rely on a "guess and test" strategy for example, the teacher would probably want to motivate these students to think before trying. Whereas for those who are at lost, the teacher would probably choose to readjust the level of difficulty of the exercises, reexplain the concepts and so on.

Note that the partitioning of students into these two groups would not be obtainable by only querying the database.

We have performed this clustering after the whole course took place, so we cannot validate anymore the interpretation of our results against another approach like human observations or surveys. We plan to validate this clustering approach during the coming academic year.

1.3   Conclusion

In this paper, we have reported our experiment on clustering students using their mistakes made with a web-based tutoring tool, the Logic-ITA. The key points in this experiment were (1) to choose an appropriate distance between students in a context of heterogeneous data, since the students have not necessarily attempted the same exercises, neither the same number of exercises,

nor the same level of exercises, (2) to extract useful information for the teacher about the type of difficulties and learning students had.

To perform the clustering, we have used the *two-steps* algorithm available in Clementine®, a commercial Data Mining software. To characterize further the clusters produced by the algorithm, the graphical visualization of relations has been useful. However, Clementine® does not have a plotting facility for nominal variables, thus it is not possible to plot and visualize for example *login* against *rule* on a graph. This confirms to us the need of a mining platform dedicated to a teaching context since the needs of a teacher trying to understand and evaluate his/her students' learning are different to the needs in a business context. Therefore, future work includes improving our Data Mining research tool [2], in particular its visualization facilities to help teachers in their interpretation.

Applying Data Mining to data collected from learning systems could bring new feedback to teachers, giving them unexpected insight on the learning of their students, and on their own teaching. This could lead to the concept of 'pedagogical intelligence' in a similar way as Data Mining to data from business has led to 'business intelligence'. To reach this goal, several sub-goals need to be met such as the selection of relevant algorithms and relevant ways to use them. This paper is a contribution to this sub-goal.

We plan to use similar clustering techniques to other data, in particular to some students homework in mathematics. These students have already been "clustered" using pedagogical criteria. It will be interesting to see what clusters we obtain, and how they compare with the ones already obtained by teachers.

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ISSUES ON SCHOOL E-LABORATORIES IN SCIENCE TEACHING
Virtuality, reality and gender

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Abstract: Gender issues and severe related problems have been discussed in the context of using modern technologies over a long period of time. Similar discussions have concerned science teaching, especially the problems of physics education and female students. Finland has been one of the most advanced countries in the implementation of modern technologies, but even here there are several open problems. We have collected data on the use of different pedagogical approaches in modern learning environments in the context of science teaching. We have national survey data from Finland (3,626 lower secondary school students and 184 teachers, and 2,661 upper secondary school students and 81 teachers). These data show that both teachers and students have rather similar ideas about the need to develop versatile pedagogical approaches including the more active use of e-learning tools and tools available for modern science classrooms like Microcomputer Based Laboratory. This means also that a balance is needed in the roles of virtual and real components of learning environments. Male students were dissatisfied with the present situation of e-learning in science. Both genders wished for more frequent e-learning with more variety. We even performed a case study actively engaging in developing science teaching in a modern learning environment yielding more detailed and qualitative data in the context of a virtual school project. We discuss the benefits of such a research-and-development project even for in-service training of teachers.

Key words: ICT use, self-evaluation, science teaching, gender

1.   INTRODUCTION

The quality of education is considered in all industrialised countries to be of high political priority. ICT attainment and the use of ICT in schools are generally considered to be appropriate indicators of the quality of education (cf. Directorate-General for Education and Culture, 2001). Other indicators we are especially interested in include science and teacher education. The challenges of the information society and the struggle to achieve high-quality education have led several countries to publish strategies to be implemented also in educational institutions (e.g. SETRIS, 2000). Finland can be considered here as an interesting case among countries with a well-developed infrastructure of an information society. Sinko and Lehtinen (1999) reported the outcomes of a large national evaluation project in Finland. This survey of the status of the use of ICT in schools gave a general view of the problems, but we need more in-depth information about ICT use in science education to evaluate current research-and-development projects and establish new ones. Ilomäki and Rahikainen (2001) studied even secondary school teachers' and students' use of and skills in ICT by gender.

Our focus is on the challenges of designing modern learning environments for school science laboratories and the related needs for teacher education. A science teacher is the main facilitator for active, collaborative and goal-oriented science teaching and learning. Teachers' roles and their beliefs about ICT have been found to have a critical influence on the students' use of ICT. It is crucial that modern technologies are utilised extensively and in a goal-oriented way if the benefits of technology-enhanced learning can be expected to materialise. These issues may be far more important than problems regarding the access to hardware or software. There have been many studies indicating that modern technologies are not used in schools even when available. Also gender issues and gender-related severe problems have been discussed in the context of using modern technologies over a long period of time. It has been supposed that the low percentage of female computer science students reflects a severe problem, as well as an opportunity to recruit a substantial pool of professionals in this field. Similar discussions have concerned science education, especially the problems of physics education and female students.

The effectiveness of ICT use in science education depends, for example, on the teacher's understanding of how to use ICT. It also depends on the teacher's personal knowledge of the concepts involved, and on their ability to help students link their experiences to related concepts. We can refer here even to the use of the Vygotskian idea of the zone of proximal development and scaffolding (e.g. Jonassen, Mayes, & McAleese, 1992) and to the ideas of creative problem solving. Furthermore, it depends on their ability to

encourage interaction among students to talk about information available from different sources, and on their ability to develop teaching and learning approaches suitable for ICT uses (Lorsbach and Tobin, 1995; Maor and Taylor, 1995).

It is known that students will learn better if they are interested in the topic to be learnt. The motivation to study science depends on several factors and attributes like students' interest and attitude (Fairbrother, 2000, 16–17). Typically, answers to what might motivate students are sought by investigating their interest in, or attitude towards, science (i) in general (or domains of science or content), (ii) in context (e.g., science in society or technology) where a certain science domain is met, and (iii) in the type of activity (including ICT use) or method of studying the subject or in the teaching methods used (Osborne, 2003). One important medium that affects student interest and learning is ICT use in science education. Therefore, it is important to clarify what kinds of ICT use interest students. According to modem psychological theories (Hoffmann, 2002), interest in science can be seen as a psychological construct that emerges from the student's interaction with (physical) objects and phenomena and explanations of them and, moreover, with science as a school subject. Interest can be seen as a medium supporting learning processes and the quality of learning. In this study, we register student interests through their wishes concerning ICT use.

In the present research, the first research question focuses on the students' and teachers' self-evaluation, how often different types of ICT are used in science education in the present-day situation, and how often students and teachers would like to use them in Finnish lower and upper secondary schools. The second research question concerns the possibility to enhance versatile ICT use in schools by a project with open teacher-researcher collaboration: How students evaluate ICT use after a three-year research and development project.

2. EMPIRICAL APPROACH

2.1 A national survey in Finland

For the survey, 75 schools were randomly selected, weighted by the number of students in grade 9, from the list of all secondary schools in Finland. In each selected school about 65 students were asked to answer the survey. In most cases this means three classes in the school. In one school there were only 20 students, in two about 30 students and in two about 40 students. Our stratified sampling approach means that the students were

selected essentially in random from the whole age cohort. Altogether, there were about 60,000 students in grade 9 in spring 2003 and we selected 4,954 pupils for the survey and 3,626 pupils answered. The questionnaire included many items concerning students' ideas about science and science education. Here, we analysed the seven items concerning ICT use in science education. A similar procedure and the same questionnaire was used in upper secondary schools, where the number of schools was 477 and the number of second graders by the end of the spring term was 38,900 and 2,661 of these students answered the survey. Moreover, their teachers answered the same questionnaire, that is 184 lower secondary and 81 upper secondary school teachers.

As the basis of the questionnaire, and as the basis of our research and development efforts, the ICT use was categorised into *(A) tool applications or tool software* and *(B) ICT use in learning (learning through ICT)* (Moursund & Bielefeldt, 1999; Webb, 2002). In the *tool category (A),* ICT is treated as a set of available software enabling people to accomplish their tasks in a more efficient way. Therefore, we developed the use of general office software, word processors and spreadsheets in science education. The main uses of *ICT in learning (B)* can be divided into three different uses for directly supported learning: (i) Computer-assisted learning (CAL) is any interaction between a student and a computer system designed to help the student learn. CAL includes, for example, simulations (applets in the Internet) and virtual-reality environments. (ii) Computer-assisted research is the use of ICT as an aid in collecting information and data from various information sources with the emphasis on the use of ICT in supporting scientific reasoning (McFarlane & Sakellariou, 2002). Typically, these investigative activities are conducted in small collaborative groups (Wiesenmayer & Koul, 1998) where ICT is used as an agent for interaction with information source, like Internet or nature or in schools, often in Microcomputer-Based Laboratories (MBL). (iii) Distance learning in a natural way has evolved from using only regular mail to using all available IT services adjusted to fully facilitate the students' learning. Thus, modern distance learning solutions are based on a wide range of communication technologies, such as course management systems (e.g. WebCT), and two-way audio/video teleconferencing (Davies, 1998).

The aim of the questionnaire designed for the present survey was to clarify how ICT is used in teaching now and how students would like to use them in studying in lower and upper secondary schools. A general description of a preliminary study has been reported by Lavonen, Juuti, Byman, Meisalo, Koponen & Saloranta (2003) and the questionnaire was refined on the basis of this pre-review.

The questionnaire was sent to the selected schools on 27 March 2003 and the headmasters were asked to organise the survey. They were also asked to send the completed questionnaires back by 20 April 2003. In the covering letter, the national and international purposes of the survey were carefully explained. For example, it was explained how a new kind of in-service training can be organised by the National Board of Education based on the information acquired by the survey. The letter was signed by the Head of the Department of Teacher Education and the Chief Director of the National Board of Education.

Altogether, 26 reminders (37 % of selected schools) were sent on 10 May 2003 to those headmasters who had not organised the survey on time. The purpose of the survey was again explained to them and they were asked to return the filled questionnaires by 25 May 2003. The survey was answered by 3,626 students in 61 schools, which corresponds to 73% of pupils in 81% of the selected schools. A similar procedure was used in the upper secondary schools. The questionnaire was sent to 49 schools, 44 of them answered yielding data on 2,661 students and 81 teachers.

2.2   A case study

We launched a three-year virtual school project, the Finnish Virtual School of Science Education (FVSSE), in autumn 2000. In the beginning of the project there were 31 science teachers. Twenty five science teachers actively participated for most of the project. They had an average of 10 years teaching experience. More than two thirds of the teachers were qualified upper secondary school teachers, while the rest were lower secondary school teachers. About one quarter of the teachers taught chemistry or mathematics and almost half physics as the main subject. The project was active for three years and the responsibility for designing the activities was gradually transferred from the researchers to the participating teachers. The possibilities of ICT use in science education within the FVSSE was discussed in the framework of active teaching and learning. "Active" means that students are guided and involved in collaborative learning processes (Hodson, 1998, 34-43). The students may search for information themselves or collaboratively from library resources or from the Internet and, of course, through investigations in nature and, furthermore, in the man-made environment during field trips and visits. Therefore, students' knowledge was considered a result of their active role in the creation of meanings for new concepts based on information available, their prior knowledge, as well as individual and social experience (Masui & De Corte, 1999). On the other hand, students' learning should be, of course, facilitated through the active intervention of a teacher who knows the structure of science, the nature of

cognition as an adaptive process, and what the students already know (Novak, 1998) and, furthermore, a meaningful way of using ICT in education (Cohen, 1997).

In the very beginning of the FVSSE, it was decided that ICT use in science education should be planned and developed on the basis of the school science curriculum and, therefore, it was important to discuss ICT use in investigations and other practical activities (cf. McFarlane and Sakellariou, 2002). Teachers became especially familiar with computer-assisted research. For example, Microcomputer-Based Laboratories were used in measurements, spreadsheet in organising and presenting the data, the Internet as a source for information, and word processing in publishing outcomes of investigations and other tasks. Because ICT has become increasingly important due to the growth of the World Wide Web (e.g., virtual libraries and databases) etc., teachers concentrated on activities where the Internet was the source of information. They considered it important to know how this information can be processed so that students can acquire new knowledge and become familiar with the scientific reasoning, (e.g., learn to distinguish statements that are not true or to control variables or to test hypotheses, cf. Millar, 1996, 15). In the Finnish National Framework Curriculum (NBE, 1994), which had to be followed in these teaching experiments, there is also a description of how *ICT should* be used in physics and chemistry education: *"The teaching in physics and chemistry can be diversified by using ICT in measurements, data analysis, model construction, analysis of knowledge, and in reporting."*

Different distance learning approaches were both the means and the content within the FVSSE. Electronic mail, newsgroups, chat rooms and videoconferencing were also intensively used for educational purposes. The use of newsgroups was chosen as the main distance working method. Several different course management systems (e.g. WebCT and Humap Kids) were used in teaching experiments. For example, two groups of students in different schools co-operated in the project *"Life cycles of different types of glass"*.

The selection and designing of the FVSSE activities and the project evaluation were also based on self-evaluation data on teachers' ICT competencies and the equipment available in their science classrooms. There was a wide spectrum of competencies, as well as areas where all teachers felt unconfident with their skills. Therefore, in the beginning of the FVSSE we concentrated on developing ICT use in science education within those areas where teachers themselves were competent. An important aspect of the function of the FVSSE was that the detailed planning of teaching experiments was the responsibility of the participating teachers. They

performed most valuable development work in the practical designing of the pedagogical approaches.

3.   RESULTS

3.1   Survey data

The data on ICT use we report in the present paper have been collected using the scale of evaluation: 1 never; 2 rarely (1-4 times a term); 3 sometimes (2-4 times a month); 4 often (2-3 times a week); 5 daily (almost every school day). Even the differences between the current situation and the wishes are shown in the Tables 1 - 4. The frequencies of ICT use in science education – current use and hoped-for use – are compared with the Wilcoxon Signed-Rank (Z-values) Test. It is a non-parametric test used with two related variables to test the hypothesis that the two variables have the same distribution. It makes no assumptions about the shapes of the distributions of the two variables. The test takes into account information about the magnitude of differences within pairs and gives more weight to pairs that show large differences than to pairs that show small differences. This test is used here to compare if there are statistically significant differences in the distributions of two variables: how often a certain ICT category is currently used and how often it should be used. Negative (student like less of a certain ICT use) and positive differences in the opinions of students are calculated. The distributions of male and female students (and students vs. teachers) are compared using a Chi-Square Test, which tests the hypothesis that the row and column variables are independent. The direction of the relationship was analysed from the cross-table so that it was possible to say which group had or wished to have the teaching method concerned more frequently. Table 1 shows lower secondary school students' (n_{male} = 1641, n_{female} = 1794) evaluations of how often different types of ICT use are seen in practice currently in learning physics and chemistry.

The data show that the evaluations of the current situation of the ICT use is rather similar with male and female students. Even their wishes are not very different. Here, we may conclude on the basis of median differences that female students have experienced ICT use less often than male ones. The gender differences in the wishes of male and female students is statistically significant.

Table 1. Lower secondary school students' (n_{male} = 1641, n_{female} = 1794) evaluations of how often different types of ICT use are currently activated in learning physics and chemistry and how often they should be used.

Different types of ICT use	[2]	Current (A)		Wish (B)		Differences between B and A		$Z^{1)}$
		Md	Mo	Md	Mo	Neg	Pos.[3]	
ICT tools (Word, Excel)	M	2	1	3	3	246	756	15.1***
	F	1	1	2	3	132	808	20.5***
Internet (information retrieval)	M	2	1	3	3	224	860	19.0***
	F	2	1	3	3	103	1004	25.1***
Videos, films,	M	2	2	3	3	238	802	16.8***
	F	2	2	3	3	134	858	21.4***
Computer assisted learning,	M	2	1	3	3	229	829	17.8***
	F	1	1	2	2	126	853	21.3***
E-mail or newsgroups	M	1	1	3	3	207	759	16.6***
	F	1	1	2	1	89	912	23.6***
Learning management systems	M	2	1	3	3	217	699	15.1***
	F	1	1	2	1	79	808	22.1***
MBL	M	2	1	3	3	230	602	11.4***
	F	1	1	2	1	116	573	15.6***

1) [ns] $p > 0.05$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$
2) M = male, F = female
3) Md = median, Mo = mode, Neg. = Negative ranks, Pos. = Positive ranks

Table 2 shows students' and teachers' ($n_{Student}$ = 3626, $n_{Teacher}$ = 184) evaluations of how often different types of ICT use are currently activated in learning physics and chemistry and how often they should be used, evaluated using the same scale as above. It seems that the evaluations of the current situation of the ICT use are similar for students and teachers. Even their wishes are not much different. However, the students wish for somewhat more use of CAL, simulations and learning management systems. Teachers put more importance on MBL applications, but see no need for learning management systems.

Table 2. Lower secondary school students and teachers' ($n_{Student}$ = 3626, $n_{Teacher}$ = 184) evaluations of how often different types of ICT use are currently activated in learning physics and chemistry and how often they should be used.

Different types of ICT use	3)	Current (A)		Wish (B)		Differences between B and A		$Z^{1)}$
		Md	Mo	Md	Mo	Neg. (%)	Pos.(%)$^{2)}$	
ICT tools (Word, Excel)	S	2	1	3	3	381 (11)	1573 (43)	25.0***
	T	2	2	3	2	0 (0)	108 (59)	9.7***
Internet (information retrieval)	S	2	1	3	3	328 (9)	1875 (52)	31.2***
	T	2	2	3	3	0 (0)	87 (47)	9.7***
Videos, films	S	2	2	3	3	373 (10)	1673 (46)	27.0***
	T	3	3	3	3	1 (1)	42 (23)	6.0***
Computer assisted learning	S	2	1	3	3	358 (10)	1690 (47)	27.4***
	T	2	1	2	2	1 (1)	93 (51)	8.9***
E-mail or newsgroups	S	1	1	2	1	296 (8)	1685 (46)	28.5***
	T	1	1	2	1	0 (0)	76 (41)	8.0***
Learning management systems	S	1	1	2	1	298 (8)	1518 (42)	26.2***
	T	1	1	1	1	0 (0)	67 (36)	7.7***
MBL	S	2	1	2	1	351 (10)	1185 (33)	18.9***
	T	1	1	2	2	0 (0)	101 (55)	9.0***

1) ^{ns} p > 0.05, * p < 0.05, ** p < 0.01, *** p < 0.001
2) Md = median, Mo = mode, Neg. = Negative ranks, Positive = Pos. ranks
3) S = student, T = teacher

The data in Table 3 illustrate upper secondary school students' (n_{male} = 1174, n_{female} = 1487) evaluations of how often different types of ICT use are seen in practice currently in learning physics and chemistry. The scale of evaluation is the same as above. It seems that the evaluations of the current situation of the ICT use are similar for male and female students. In addition, the differences are even smaller than in the lower secondary schools. However, there were statistically significant gender differences in the wishes with female students not wishing to use e-learning, learning management systems or MBL as much as males. The important feature seems to be both genders wishing to use ICT more often than they have experienced in the present situation.

Table 3. Upper secondary school students' (n_{male} = 1174, n_{female} = 1487) evaluations of how often different types of ICT use are currently activated in learning physics and chemistry and how often they should be used.

Different types of ICT use	[2]	Current (A)		Wish (B)		Differences between B and A		$Z^{[1]}$
		Md	Mo	Md	Mo	Neg.	Pos. [3]	
ICT tools (Word, Excel)	M	2	1	3	3	91	541	16.8***
	F	2	1	2	3	166	586	15.3***
Internet (information retrieval)	M	2	1	3	3	94	565	17.7***
	F	2	1	3	3	107	709	20.2***
Videos, films	M	2	2	3	3	86	616	19.0***
	F	2	2	3	3	103	800	22.2***
Computer assisted learning	M	2	1	3	3	93	550	17.1***
	F	1	1	3	3	68	747	21.7***
E-mail or newsgroups	M	1	1	2	1	70	392	14.2***
	F	1	1	1	1	44	519	18.2***
Learning management system	M	1	1	2	1	75	418	14.7***
	F	1	1	2	1	44	568	19.4***
MBL	M	2	1	3	3	123	362	10.7***
	F	2	1	2	3	114	408	12.8***

1) ^{ns} p > 0.05, * p < 0.05, ** p < 0.01, *** p < 0.001
2) Md = median, Mo = mode, Neg. = Negative ranks, Positive = Pos. ranks
3) S = student, T = teacher

Table 4 shows upper secondary school students' and teachers' ($n_{Student}$ = 2661, $n_{Teacher}$ = 81) evaluations of how often different types of ICT use are currently activated in learning physics and chemistry and how often they should be used, evaluated using the same scale as above. Again, the evaluations of the current situation of the ICT use are similar for students and teachers, few modes in the student data being lower. Even their wishes are not much different. The important feature seems to be the wish of both teachers and students to use ICT more often than they have experienced in the present situation. However, somewhat problematic may be that neither teachers nor students wish to use learning management systems much (even if somewhat more than presently used).

Table 4. Table 4. Upper secondary school students and teachers' ($n_{Student} = 2661$, $n_{Teacher} = 81$) evaluations of how often different types of ICT use are currently activated in learning physics and chemistry and how often they should be used.

Different types of ICT use	[3]	Current (A)		Wish (B)		Differences between B and A		$Z^{[1]}$
		Md	Mo	Md	Mo	Neg. (%)	Pos.(%)[2]	
ICT tools (Word, Excel)	S	2	1	3	3	257 (10)	1127 (42)	22.0***
	T	2	2	3	3	0 (0)	44 (54)	6.1***
Internet (information retrieval)	S	2	1	3	3	201 (9)	1274 (48)	26.7***
	T	2	2	3	3	0 (0)	38 (47)	5.8***
Videos, films	S	2	2	3	3	189 (7)	1416 (53)	29.2***
	T	2	2	3	3	1 (1)	29 (36)	4.8***
Computer assisted learning	S	1	1	3	3	161 (6)	1297 (49)	27.5***
	T	1	1	2	2	0 (0)	51 (63)	6.5***
E-mail or newsgroups	S	1	1	2	1	114 (4)	911 (34)	23.0***
	T	1	1	2	2	1 (1)	38 (47)	5.4***
Learning management system	S	1	1	2	1	119 (4)	989 (37)	24.2***
	T	1	1	2	1	0 (0)	36 (44)	5.3***
MBL	S	2	1	3	3	237 (9)	770 (29)	16.6***
	T	2	2	3	3	1 (1)	47 (58)	6.0***

1) [ns] $p > 0.05$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$
2) Md = median, Mo = mode, Neg. = Negative ranks, Positive = Pos. ranks
3) S = student, T = teacher

3.2 Comparison with the case study

Table 5 shows a comparison of the lower secondary school students' in our national survey (NS, $n_{NS} = 3626$) and the FVSSE case study students' ($n_{FVSSE} = 85$) evaluations of how often different types of ICT use are currently activated in learning physics. In almost all categories, the case study students have experienced much more use of different types of ICT. The use of MBL is the only difference where both student population data have exactly the same medians and modes.

Table 5. Average lower secondary school students' (national survey, ASNS) and FVSSE students' ($n_{ASNS} = 3626$, $n_{FVSSE} = 85$) evaluations of how often different types of ICT use are currently activated in learning physics and chemistry.

Different types of ICT use	Group	Md	Mo
ICT tools (Word, Excel, ...)	ASNS	2	1
	FVSSE	3	3
Internet (information retrieval)	ASNS	2	1
	FVSSE	4	3
Computer assisted learning,	ASNS	2	1
	FVSSE	2	2
E-mail or newsgroups	ASNS	1	1
	FVSSE	3	3
Learning management systems	ASNS	1	1
	FVSSE	2	2
MBL	ASNS	2	1
	FVSSE	2	1

The comparison of the survey data and data of the case study is problematic. However, it seems natural that in the experimental project group essentially all ICT uses are more often activated than in average schools. It is interesting to note that MBL gets a low-frequency evaluation in both groups.

4.   DISCUSSION AND CONCLUSIONS

We defined the focus of this research to be how ICT is used in science education from the students' and teachers' perspectives now, and how students and teachers would like it to be used in lower and upper secondary schools in Finland. In general, the evaluations of the current situation of the ICT use, as well as the wishes, appear rather similar with male and female students. However, female students have experienced ICT use significantly less often than male ones. Also the gender differences in the wishes of students are statistically significant. Further, the evaluations of the current situation of the ICT use are similar also with students and teachers. Even their wishes are not much different. However, the students wish somewhat more use of CAL, simulations and learning management systems. Teachers put more importance on MBL applications.

We find, however, that it is important in interpreting the above differences to note that such a survey with large group sizes may yield statistically significant differences even when these are relatively small and perhaps not so important. Altogether, this study gives indications of where the optimal balance of using different types of ICT uses in schools might be, if teachers' and students' wishes are observed.

The second research question concerned the possibility to enhance versatile ICT use in schools by a project with open teacher-researcher collaboration. This problem was approached by the comparison of the survey data and data of the case study. The qualities of these data are substantially different and any comparisons should be made with caution. However, it seems natural that in the experimental project group essentially all ICT uses are more often activated than in average schools. It is most interesting that according to the median and mode data the situation in the FVSSE schools (Table 5) seems to be rather close to the situation outlined by the wishes of the survey schools (Table 1).

It is to be noted that MBL gets low frequency evaluation in both groups. However, the current framework curriculum in Finland emphasises the experimental nature of modern sciences and there is a huge potential in enhancing learning in school science laboratories by the active use of MBL. There are some problems with the accessibility of modern MBL software and hardware in schools, but there are indications that this is not the critical bottleneck (cf. Sinko & Lehtinen, 1999). It means that this is perhaps the most important challenge to our future research and development projects. We have actually started work on attaining these goals several years ago (e.g. Meisalo & Lavonen, 1997; 1999). It seems that teachers, as well as learners, need quite a lot of scaffolding at least occasionally, and this can be organised even over the Internet (Juuti, Lavonen, & Meisalo, 2003). The other conclusion of our study is that the innovative development of new pedagogical ICT uses by teachers helps in the activation of e-learning. This kind of effort may be recommended for further research and development activities.

Our study did not extend to lower grades of the comprehensive school. However, it seems that one of the problems is the lack of motivation to use, and negative attitudes towards, ICT. It is obvious that pupils should have ample opportunities to enjoy e-learning in science already during their first school years. The on-going curricular reform the National Framework Curriculum in Finland will open doors for teaching chemistry and physics on grades five and six. There is currently a huge need for in-service training of teachers and we have produced a versatile learning environment with both a virtual and a real component available for schools (Juuti, Lavonen, Kallunki, & Meisalo, 2003; Juuti, Lavonen & Meisalo, 2004). In further research within this project, the emphasis will be on the dissemination of the idea of using the environment in a versatile way for studying and enjoying learning. This seems to give more benefits to girls as well as boys so that both genders have equal opportunities for further studies in science.

To reach gender equality in science education, it is not enough to focus on uses of ICT (as in this research) or teaching methods (Lavonen, Juuti,

Meisalo, Uitto, & Byman, 2004), it is important as well to focus on pupils interests in different contexts. Students', especially female students' interest to study physics is very sensitive to changes of contexts where physics topics are met. In another paper (Juuti, Lavonen, Uitto, Byman, & Meisalo, 2004) reporting a national survey, we showed that female and male students are equally interested to study physics in the context of human being. Therefore, suggested approach could be to integrate ICT in studying physics in human being context. There were more gender differences in wishes in ICT use for lower secondary than upper secondary school students. It is obvious that ICT use should be planned with care. Female and male students wished equally more information retrieval to be used in schools (Table 1). Thus, an interesting teaching experiment could be based on the idea that pupils search in the Internet examples on how studied phenomena, physical concepts and laws appear in human beings. An example could be a study of perspiration as thermal control of human body.

The gender equality challenge remains quite important, but there are in our present study some indications of how the gender differences in interests in science learning or ICT use may be diagnosed and utilised for providing equal opportunities for both male and female students for gaining understanding in relevant problems and participating in science and technology studies as well as entering related professions.

ACKNOWLEDGEMENTS

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COMPUTER-AUTOMATED TESTING: AN EVALUATION OF STUDENT PERFORMANCE

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Abstract   In the last few years, the need for an automated way to assess people has increased quickly because of the growing request from both private and public structures. Many Learning Management Systems (LMS) have been developed in order to automatize the learning and assessment process. In most of the cases these systems don't allow a quality content evaluation and an efficient ability estimation. In this paper we analyze the features of the Proportional Odd Model (POM), belonging to the Item Response Theory. The POM enables to translate an automatic test deliver in an efficient way in order to get an evaluation through either a summative or a formative way. The data have been collected in some undergraduate courses of Bologna University, by using test delivering and by authoring system developed in ASP and Java, respectively.

Keywords: Automatic test deliver, automatic evaluation system, undergraduate students ability system, IRT models for ordered polytomous variables.

Introduction

In the Italian educational system the increasing level of formative requirement needs a particular consideration in the assessment and evaluation field. The assessment, defined as process of measuring learning, is a problematic component of the most e-learning programs. Each automatic evaluation system requires the introduction of methodological statistical tools.

Within a new way of understanding the assessment process of a student, eval-

uation may serve two complementary functions. In one context, the aim is prospective, or *formative* - to improve, to understand strengths in order to amplify them, or to isolate weaknesses to mend. Formative evaluation is a process of ongoing feedback on performance.

The other context is retrospective, or *summative* - to assess concrete achievement, perhaps as part of a process of acknowledgement or giving awards. Summative evaluation is a process of identifying larger patterns and trends in performance and judging these summary statements against criteria to obtain performance ratings.

Before new methodologies realize their fullest potential we must expand our basic mental model of what they are [Gentner and Stevens, 1983]. Cognitive psychologists define mental models as the way to understand and analyze a phenomenon. That is, people have different mental models of e-learning, depending on their attitude to it and their experiences with it. It's very important to focus our attention on the assessment problem of a examinee performance. We have to conceive it like the exterior expression of a set of latent abilities. The statistical evaluation of these abilities and its transformation into a mark are the principal aims of this work.

In our particular case we consider an experimental project developed at the University of Bologna based on an automatic evaluation system applied in different steps of the educational offer.

In this paper we intend to investigate the efficacy of a test delivering system that automatizes the task to submit and correct a test. In a computer-based testing, there are many issues to be considered: test administration, the impact that the system will have on examinees and the way to assign a final mark.

1.   The system description

The systems used to deliver our tests have approximately the same functions even if they have been developed in two different architectures. The first one, "Examiner", has been developed by using ASP (Active Server Pages) technologies and Access as Database Management System. The second one, "XTest" has been developed, following the experience of the first system, in Java/JSP (Java Server Pages) and mySQL as DBMS to make it platform independent.

The task performed by these systems is to manage questions of various type, by creating randomized tests for an exam given some constraints on contents and by delivering them to a client application. For Examiner, the questions are delivered as HTML text to a web browser that renders them on the screen, whereas for XTest there is a Java Applet that receives data from a server application launched from a machine. The machine acts as control console. The main advantage of the first solution is the minimal requirements of client system resources so that only a compatible browser HTML 1.0 is needed in order

to run the client application. The second solution needs a JRE (Java Runtime Environment) to be installed on the client machine. A Java Applet has more potential in creating new questions type and in a large distributed environments. Furthermore, it allows to have less computational loading on the server.

In such a systems the teacher has to create and insert some questions that are grouped by their subject topics. In a successive phase, he was to decide how to build the test for the session.

Each item is shown to the student through a window in which he has to put his answer. A typical case is an item that displays a Prolog algorithm selecting all negative numbers from a list of integers and inserting them to on output list. The examinee has to understand what the Prolog code does and to select the interpreter output. The examinee has to understand what the *Prolog* code does and has to select the interpreter output.

The courses concern basic competencies on Computer Science and Prolog programming. The courses have been divided in five topics:

GLOSSARY : the questions belonging to this topic ask for the meaning of some words or the functions of some objects of the computer world;

FOUNDATIONS : this topic concerns basic knowledge on calculability, algorithms complexity, computer architecture, compiler and programming languages;

PROLOG : question that asks to interpret or complete some parts of Prolog source code;

PROLOG01 : this topic is about the Prolog syntax;

PROLOG02 : this topic is about the problems formalization in Prolog.

The item type chosen for student assessment is a closed answer type. In particular, even if the systems are able to manage more than one item type, the multiple response questions have been used. This kind of question consists of a text representing the question itself and of a list of n possible answers that the examinee has to check if the answer is right. A score is associated to each answer. It is positive if the answer is right and negative otherwise. A zero score is assigned to not checked answer. The sum of the single scores gives the exercise result.

The questions are presented to the student sequentially and if they are checked, the student is not allowed to review them. Otherwise he can review it once again. Furthermore the questions are randomly presented so that each test seems to be different from each other.

2.   The statistical evaluation: the ability as latent trait

Usually the analysis of the results of a test is not taken into account independently from the formulation of the questionnaire. In the classical test theory, each item is evaluated through a score and the *total score* permits to give a mark to the examinee.

At the beginning of the sixties a new methodology, called *Item Response Theory* (IRT) [Lord and Novick, 1968] has been developed: it allows to evaluate the student ability, the question difficulty and the capability of the item to distinguish between examinees with different ability. Since ability is not directly observable and measurable, it is referred to as latent trait. Thus an IRT model specifies a relationship between the observable examinee text performance and the unobservable latent trait (ability) that is assumed to underlie the test result. A mathematical function permits to describe the relationship between the "observable" and the "unobservable" quantities. This function is called *Item Characteristic Curve* (ICC) and it determines the probability to answer correctly to an item on the basis of a given ability examinee level, through the ICC.

The ICC is described by parameters (constants) whose number depends on the specific chosen IRT model. In general one constant represents the *difficulty* of the item, that is, a high value of the parameter implies a high level of complexity. An other parameter, called *discrimination power,* is used to quantify the capability of the question to distinguish between examinees with different ability level.

After the estimation of the parameters it is possible to determine the examinee ability that is transformed into a mark by a function illustrated below (see par. 4.3).

Unlike classical test models the IRT presents different advantages, but the most important is that it allows to estimate a student ability on the same ability scale from any subset in the domain of items that have been fitted to the model [Hambleton and Swaminathan, 1985]. An ability estimation which is independent of the number and the choice of items represents one of the most important advantages of IRT models. They provide a way of comparing students even though they have taken different subset of test items. Assuming a quite large population of examinees, the parameters of an item are independent of the particular sample of students.

3.   Model   specification

In this work we apply a particular IRT model called Proportional Odds Model (POM) introduced with the aimto treat the case of ordinal observed variables. Problems with different levels of complexity have been included in each argument (item). In fact, the problem solving process contains a finite number of steps so that the student ability can be evaluated on the basis of the step

achieved. In this way, for the *i*-th item an ordinal score m_i is assigned to the examinee who successfully completes up to step m_i but fails to complete the step $m_i + 1$. Following this procedure, a score ranging from 1 to 4 is assigned to each examinee for each item with respect to the solving level achieved (1=no correct answers, 2=correct answers only for preliminary problems, 3=correct answers also for intermediate problems, 4=all correct answers).

Let $x_1, x_2, \ldots, x_p$ be p ordinal observed variables regarding the items of a questionnaire and let m_i denote the number of categories for the *i*-th variable. The m_i ordered categories have probabilities $\pi_{i1}(z), \pi_{i2}(z), \ldots, \pi_{im_i}(z)$, which are function of z, the latent trait representing the individual ability. They are known as *category response functions*. Indicating with $\mathbf{x}_r = (x_1, x_2, \ldots, x_p)$ the complete response pattern of the *r*-th individual examined, we can define the probability of $\mathbf{x}_r$ as:

$$\pi_r = \int_{-\infty}^{+\infty} \ldots \int_{-\infty}^{+\infty} \pi_r(z)h(z)dz \tag{1}$$

where $h(z)$ is assumed to be a standard normal and $\pi_r(z)$ is the conditional probability $g(\mathbf{x}|z)$. For g the conditional independence is assumed, that is when the latent variable is held fixed, the p observed are independent. In the case of ordinal observed variables it is defined as:

$$g(\mathbf{x}_i|z) = \pi_r(z) = \prod_{s=1}^{m_i} \pi_{is}(z)^{x_{is}} = \prod_{s=1}^{m_i} (\gamma_{is} - \gamma_{is-1})^{x_{is}} \tag{2}$$

where $x_{is} = 1$ if a randomly selected person responds in category s of the *i*-th item and $x_{is} = 0$ otherwise and $\gamma_{is} = \pi_{i1}(z) + \pi_{i2}(z) + \ldots + \pi_{is}(z)$ is the probability of a response in category s or lower on the variable i. γ_{is} is know as *cumulative response function*. The model is defined in terms of a logit function of γ_{is} and can be expressed in a general form within the generalized linear models framework as Moustaki (2000):

$$logit(\gamma) = \ln \left[\frac{\gamma_{is}(z)}{1 - \gamma_{is}(z)} \right] = \alpha_{is} - \beta_i z \quad , \qquad s = 1, 2, \ldots, m_i - 1 \tag{3}$$

The model so defined is called Proportional Odds Model (POM) and is very similar to the well known Graded Response Model by Samejima (1969). It ensures that the higher is the value of an individual on the latent variable, the higher is the probability that individual belongs to a higher item categories. The intercept parameter α_{is} can be interpreted as the item *difficulty* parameter whereas β_{ij} can be interpreted as the *discrimination* power parameter. To define ordinality properly, the condition $\alpha_{i1} < \alpha_{i2} < \ldots < \alpha_{im_i}$ must hold. The parameters of the model are estimated using the maximum likelihood estimation

by an E-M algorithm. At the step M of the algorithm a Newton-Raphson iterative scheme is used to solve the non-linear maximum likelihood equation. To score the individuals on the latent variable we can refer to the mean of z defined as:

$$\int zh(z|\mathbf{x}_r)dz$$

where $r = 1, \ldots, n$. These values are normally distributed as given by the previous assumptions.

4.   Analysis and results

4.1   Data collection

Data used in our analysis were collected in various exam sessions of different courses of Computer Science at the University of Bologna. We have grouped the items score together for each argument and normalized it in order to elaborate it by using each model. We have chosen to treat the arguments as "macro items" and to model it as a ordinal items with four answer categories, as described before.

We have considered a sample of 704 students who have written the exam of Computer Science. As for the description of the computer test results, Table 1 shows the percentage and cumulative percentage distributions for each argument.

Table 1.   *Percentage and Cumulative percentage distributions*

	Category 1	*Category 2*	*Category 3*	*Category 4*
Glossary	1.70	14.63	43.18	40.48
Prolog1	5.97	41.62	40.48	11.93
Prolog2	18.89	50.57	21.73	8.81
Prolog	10.51	53.69	24.00	11.79
Foundat	10.23	52.70	33.24	3.84

We can notice that *Glossary* presents the highest percentages in correspondence of the scores greater or equal to 3. On the contrary, for the *Foundations* and the three arguments concerning *Prolog* (that is *Prolog, Prolog 1, Prolog2*) the most frequent score is 2. It is interesting to notice that the percentage of the students that get high scores for high categories tends to decrease from the first items to the last. That is, it seems to be very important the order of presentation of the items. Perhaps this is a probable explanation of the quite bad performance of the students for the last item. These exploratory results seem to highlight that the items that assess the programming capability and the problem

formalization are more complex to be solved than the items related to the basic knowledge.

4.2   Model results

The model estimated has 20 parameters, 3 difficulty parameters for each item and 5 discrimination parameters. The difficulty and discrimination parameter estimates for each item are reported in Table 2.

Table 2.   Parameter difficulty and parameter discrimination estimates

	α_{i1}	α_{i2}	α_{i3}	β_i
Glossary	-4.12	-1.69	0.4	0.43
Prolog1	-2.98	-0.12	2.19	0.73
Prolog2	-2.12	1.18	3.3	1.67
Prolog	-2.46	0.68	2.32	0.94
Foundat	-2.2	0.54	3.25	0.26

We can notice that the items that tend to be more difficult are *Prolog1, Prolog2* and *Foundat* since their difficulty parameters have very different values among the 3 categories and present the highest absolute values. This indicates that for these items it is very difficult for a student to get a high score and hence to have a good performance. On the other hand, the item that seems to have the lower difficulty is *Glossary* for the opposite reasons listed above. Furthermore we can observe that the item that presents the highest discrimination parameter is *Prolog2* (1.67) followed by *Prolog* (0.941). Conversely, *Foundat* is the item with the lowest discrimination value (0.257). The item *Foundat* needs particular considerations. It is possible that the order of the presentation has played an important role and the statistical design of the experiment necessarily requires to be deeply analyzed.

4.3   Student classification

The Italian university mark system fixes in 18/30 the smallest vote to pass an exam, whereas the highest mark is 30/30 *cum laude* (denoted by 30+).
The students can be classified by obtaining a vote according to the different levels of ability. The votes are assigned by fixing two extreme values that indicate, respectively, the lowest level of ability to pass the exam and the highest level of ability. The range between these extreme values is divided into intervals of equal width. A ranked vote is associated to each of them.
On the basis of the indications derived by the previous exams, we decide that the student doesn't pass the exam if ability is smaller than -0.85 ($\Phi(z) = 0.20$ where Φ is the normal distribution function) and we assign the maximum score

(30+) to the students that get a value equal or greater than 1.65 $(1 - \Phi(z) = 0.05)$. The remaining votes are given by dividing the range from -0.85 to 1.65 into 13 intervals of equal width and by associating them a score graduated from 18 to 30. In this way we can get a rule for student classification that is not influenced by the performance of specific groups of students in different sessions. That is, the vote the student receives is independent from the votes given to the rest of the students so that it is possible that all the students (or none of them) in a session pass the exam.

In Table 3 the frequency distribution of the votes are reported. We can notice that in this session only almost 10% of the students don't pass the exam whereas about the 2% of them get the maximum score. Looking at Figure 1 we can also notice that the distribution of the votes shows a slightly negative skewness, that is, the histogram presents on the left a higher slope than on the right side. This aspect indicates that the students who get a vote ranging from 18 to 23 are the most part.

Table 4 and Figure 4 show the result of a second approach to assign the marks to the examinees. This method is quite similar to the first one, it is different only for the choice of the extremes of the ability intervals. Let z_{18} be the 20th percentile and z_{30+} the 95th of the z distribution, the score is computed by the following linear transformation:

$$Score = 18 + (31 - 18)\frac{z - z_{18}}{z_{30+} - z_{18}} \tag{4}$$

where 31 is the numeric value of 30 *cum laude* (30+).

This last method treats the group of 704 examinees like a statistical population, that is, the value of z_{18} and z_{30+} will play the role of thresholds for the next exams.

In this particular case the results of two methods are quite different because the first one is based on the theoretical normality assumption of the ability and treats the set of students like a sample. Therefore the 20th and the 95th percentile are calculated on the basis of the theoretical normal model.

It is very important to underlie that the differences between the two methodologies seem to decrease if the thresholds z_{18} and z_{30+} are used to determine the marks of another students set.

Table 3.   Classification of students according to their performance (First Method)

Ability	Mark	n_i	Ability	Mark	n_i
< −0.85	< 18	76	0.50 ⊢ 0.69	25	42
−0.85 ⊢ −0.66	18	40	0.69 ⊢ 0.88	26	30
−0.66 ⊢ −0.47	19	57	0.88 ⊢ 1.07	27	35
−0.47 ⊢ −0.27	20	101	1.07 ⊢ 1.27	28	30
−0.27 ⊢ −0.08	21	77	1.27 ⊢ 1.46	29	12
−0.08 ⊢ 0.11	22	76	1.46 ⊢ 1.65	30	6
0.11 ⊢ 0.30	23	55	≥ 1.65	30+	16
0.30 ⊢ 0.50	24	51			

Table 4.   Classification of students according to their performance (Second Method)

Ability	Mark	n_i	Ability	Mark	n_i
< −0.59	< 18	140	0.41 ⊢ 0.55	25	40
−0.59 ⊢ −0.45	18	47	0.55 ⊢ 0.70	26	33
−0.45 ⊢ −0.30	19	61	0.70 ⊢ 0.84	27	20
−0.30 ⊢ −0.16	20	59	0.84 ⊢ 0.98	28	29
−0.16 ⊢ −0.02	21	62	0.98 ⊢ 1.12	29	18
−0.02 ⊢ 0.13	22	61	1.12 ⊢ 1.27	30	19
0.13 ⊢ 0.27	23	47	≥ 1.27	30+	36
0.27 ⊢ 0.41	24	32			
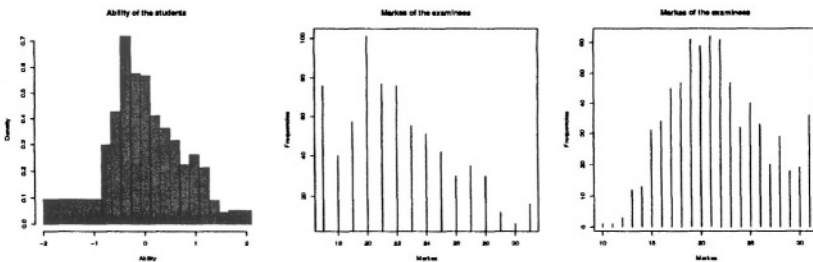
Figure 1.

5.   Conclusions

An IRT model for ordinal observed variables (POM) has been used with the aim to formalize the increasing level of complexity related to the test submitted to the students. Model estimation has highlighted inequalities among the arguments involved in, both in term of difficulty and discrimination. This inequalities have brought out different levels of ability among the students analyzed. It has been also proposed a student classification based on both the

values of the latent variable ability estimated through the model and the judge of the expert, the professor of the subject analyzed.

This is a first analysis of student ability evaluation. Further developments can be considered by improving some aspects of the IRT model, like the goodness of fit problem, and by referring to different data sets in order to consolidate the results. The statistical validation of the evaluation system permits to use this methodology to realize an *assessment in progress,* that is, to give the student a *formative evaluation.*

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A MODEL FOR DESIGNING AND EVALUATING TEACHER TRAINING PROGRAMS IN TECHNOLOGY EDUCATION

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Abstract: This paper describes a model that was successfully used for the simultaneous design and evaluation planning of a Finnish teacher training program in technology education that was carried out via computer-mediated learning. An argument for simultaneous program design and evaluation planning is given.

Key words: program design, program evaluation, technology education

1.   INTRODUCTION

Given the enormous scope and complexity of the work that program designers and evaluators do, systematic, yet adaptable, models for accomplishing their tasks are essential. This paper outlines a step-by-step model that was used for the simultaneous design and evaluation planning of the Development Project for Educational Technology (DPET). It is hoped that this simultaneous program design and evaluation planning model will be a useful template for those who have been charged with designing and evaluating similar programs.

The DPET program, which develops theory, best practices, and pedagogical tools in technology education, is a three-year program (2003-2005) supported by the European Social Fund. The first year of the program was dedicated to developing concepts of technology education in the Kids' Club research laboratory (Eronen et al., 2002), developing educational tools

(e.g., programming environments), and providing supplementary teacher education. The purpose of the supplementary education component is to increase teachers' ICT knowledge and skills so that they can take advantage of modern educational technology tools and methods in their classes. The model described here was used for the program design and evaluation planning of the supplemental teacher education aspect of DPET.

Of the many overt and covert purposes for evaluation, using evaluation as an aid to program design has been largely overlooked. This is surprising since simultaneous program design and evaluation planning brings forth mutually beneficial results.

In short, evaluation planning and program design facilitate one another. First, through preliminary evaluation activities, program goals are clarified. Second, evaluation planning helps determine the appropriate measures of progress toward program goals. Those measures can then be used as guidelines for planning program activities. Similarly, the quality of evaluation is increased when the program is designed to accommodate empirically-grounded research designs.

2.   DESCRIPTION OF THE SIMULTANEOUS PROGRAM DESIGN AND EVALUATION PLANNING MODEL

The following section describes the model used for the evaluation of the DPET program. The preliminary activities – (a) establishing the program context and rationale, (b) creating a logic model, (c) developing a stakeholder and (d) human participants matrix - are activities that benefit both the evaluation planning and program design process. The (e) evaluation planning and (f) program design steps, although they are separate entities, are complementary. The concluding and iterative steps – (g) developing implementation plans, (h) reporting plans, (i) monitoring plans, (j) data collection, analysis, reporting, and (k) modification and meta-evaluation - are steps that are necessary for both evaluation and program success and can be conducted simultaneously. See Table 1 for an overview of the model.

Table 1. Overview of the Simultaneous Program Design and Evaluation Planning Model

Procedural Steps in the Model

Preliminary Steps	
Establishing Program Context and Rationale	
Developing a Logic Model	
Creating a Stakeholder Matrix	
Developing a Human Participants Matrix	
Evaluation Planning Steps	**Program Design Steps**
Compiling Divergent Questions	Creating Program Goals
Deciding on Convergent Questions	Developing Indicators and Benchmarks
Planning for Data Collection and Analysis	Designing Program Activities
Concluding and Iterative Steps	
Creating an Implementation Plan	
Developing a Reporting Plan	
Data Collection, Analysis, and Reporting	
Program Modification and Meta-Evaluation	

2.1   Establishing the Program Context and Rationale

The first step in this design and evaluation model is to gain knowledge of the context, background, and rationale for the program. Understanding the context aids program designers and evaluators, among other things, in making culturally appropriate decisions. Being aware of the program's background assists designers and evaluators in avoiding the mistakes that past program attempts have made. Finally, understanding the rationale of the program helps designers and evaluators concretize and clarify the task that has been put before them.

In the DPET program, program practitioners and designers gave short presentations about the history of the program, the long-term goals of the program, funder expectations, and how the program fits into the wider context of other activities and programs.

2.2   Creating a Logic Model

The next step in this model is the creation of a logic model. A logic model is a graphical representation of the causal links between the program and its intended outcomes. Creating a logic model has many benefits for clarifying and codifying conceptions of what the program is and how it works. Additionally, it can serve as a guideline for creating evaluation questions when the causal links between the program and the outcomes need to be investigated.

Figure 1 is an example of the logic model created for the DPET program. It shows how the program is causally expected to lead to the desired outcomes - increased academic achievement and meaningful collaboration with the educational community.
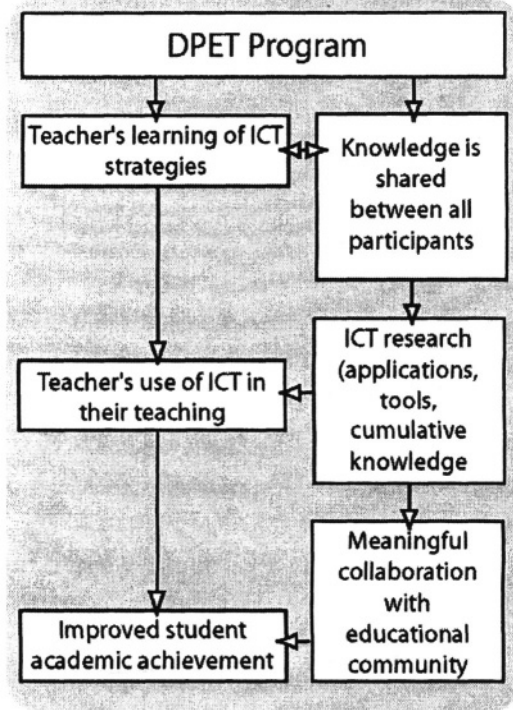
Figure 1. DPET Logic Model

2.3   Developing a Stakeholder Matrix

Creating a stakeholder matrix aids designers and evaluators in thinking about how the program will affect particular stakeholder groups. The stakeholder matrix is a document that should be considered often during the program design and evaluation process. For example, when developing divergent evaluation questions (i.e., comprehensive questions from all stakeholders), evaluation team members could roleplay what questions stakeholder groups might want answered about the program.

The first step in the creation of a stakeholder matrix is to brainstorm all of the groups that will be affected by the program. In the matrix, labels for the different stakeholder groups fill the rows while stakeholder questions fill the columns. Some of the questions asked for each stakeholder group are

listed below. See Preskill and Torres (1999) for more examples of questions that concern stakeholders.

- How will this stakeholder group be affected?
- What are the benefits to stakeholders?
- What are the risks to stakeholders?
- What are the differential effects for stakeholders?
- Should this stakeholder group be involved in the planning, execution, and reporting of the program and its evaluation?

In the DPET program the stakeholder groups were:

- Teachers/teaching assistants
- Students
- Researchers/research community
- Parents
- University administrators
- University students
- Funders
- Regional government
- The host department (the Department of Computer Science)

2.4 Creating a Human Participants Matrix

The human participants matrix functions similarly to the stakeholder matrix except that the emphasis is on how stakeholders will be affected by the evaluation. The human participants matrix reduces the possibility of unethical treatment because the evaluators systematically consider each participant group in terms of a number of ethical considerations.

The process for creating a human participants matrix is similar to creating a stakeholder matrix. First, the designers and evaluators brainstorm which groups may participate in the evaluation of the program. Labels for these groups go into the rows of the matrix and the ethical questions go into the columns. Examples of ethical questions (see Berry & Rubal, 2003) that could go into a human participants matrix are:

- Is scientifically sound action being taken regarding this stakeholder group?
- What are the risks to this group?
- What are the benefits to this group?
- Is there equitable participant selection? If not, why not?
- Are there vulnerable participants?

- Will the results be confidential? Will the results be anonymous?
- Is informed consent needed?
- Are the participants fluent in the primary language of interaction?

2.5   Evaluation Planning

After the preliminary context-oriented steps, the core of evaluation planning can take place. In this model, evaluation planning involves three main activities - developing divergent questions, deciding on a list of convergent questions (i.e., a final list of questions selected from the list of divergent questions), and making evaluation plans for each of the convergent questions. It is helpful to carry out the evaluation planning activities and the program design activities concurrently.

2.5.1   Developing Divergent Questions

Developing divergent questions is a process of collecting all of the questions that stakeholders might want answered about the program. It is useful during this phase to elicit questions from the different stakeholder groups directly. If this is not feasible, members of the evaluation team could try to predict what questions different stakeholder groups might have. For example, in the DPET evaluation planning process it was impractical to contact all stakeholders groups so evaluation team members tried to predict the different questions that each main stakeholder group would want answered. Revisiting the logic model and creating questions about the causal links is also beneficial for creating evaluation questions. As an example, a sample of 5 questions from the 29 divergent questions from the DPET evaluation plan is listed below.

- Do teachers learn to teach technology because of this program? (research-oriented question)
- Are our research methods appropriate? (meta-evaluation question)
- How much time does it take to use technology in the classroom? (teacher-oriented question)
- How does what I learn help my life and future studies? (student-oriented question)
- How does the program affect the development of North Karelia? (funder-oriented question)

2.5.2   Deciding on Convergent Questions

After the list of divergent questions is compiled, it is a matter of reducing the divergent questions to a convergent list of questions. The convergent

questions will become the final list of evaluation questions. Each convergent question will have its own data collection plan.

Depending on the context of the evaluation, there are different ways of selecting the convergent questions. If democracy is the most important factor, stakeholders might vote on the questions. Otherwise, program designers and evaluators may just decide on the questions that are most important to answer given the amount of time and resources. In the DPET evaluation, of the 29 divergent questions, 7 questions were chosen to be investigated further as convergent questions.

Sometimes it is better to concentrate on answering a few evaluation questions well rather than attempting to answer a host of questions poorly. In addition, it is important to consider the ethics of human participation, via the human participants matrix, as variables weighed into the process of choosing convergent questions.

2.5.3   Planning for Collecting and Analyzing Data

For each convergent question, a plan for reporting, collecting, and analyzing data should be made. A worksheet like the one used in the DPET evaluation, as illustrated in Table 2, could be filled out for each convergent question.

Table 2. Example of DPET Data Collection Plan Worksheet

Evaluation Question	Presentation/Report	Methodology plan	Action Plan
Do teachers learn to teach technology because of the training?	Quantitative comparisons of mastery. Qualitative self-reflection	Give a pre-post mastery checklist. Interview teachers - 'Did you learn to teach technology because of the training?'	Develop pre-post checklist - Mid January. Journal entry - Teacher evaluation activity near end of course.

For each evaluation question, the evaluation team should envision how they would like to present the results. For example, evaluators could ask themselves, "Can we answer the question with a pie chart or is it better to report qualitative data?" Based on the desired presentation, a methodology plan is devised. The final column, the action plan, specifies who will do what at what time. It is helpful at this point to have evaluation team members or consultants who are versed in research methodology to assist at this point. Excellent resources for conducting this step were written by the National Science Foundation (2004), the OERL (2004), Preskill and Torres (1999), and Weiss (1996).

2.6 Program Design – Goals, Measurements, and Activities

This section describes a method for designing program goals, measurements, and activities. A common method for designing programs is to start with the goals of the program. For each goal, measurements, indicators and benchmarks are determined. Indicators usually are considered long term or final results. Benchmarks, on the other hand, are milestones or periodic subindicators toward a larger goal. Benchmarks are useful when progress can be tracked over time. From the benchmarks and indicators, program activities are constructed. Activities are how the measurements will be affected which in turn indicate that the goals have been met. The logic of this strategy is that carrying out the program activities will lead to accomplishment of the indicators and benchmarks that show that the goals have been met. Revisiting the logic model is helpful for crafting the major and minor goals of a program.

The designers of the DPET program found it helpful to fill out a matrix, like the example illustrated in Table 3, to conceptualize the goals, measurements, and activities as part of the program design process.

Table 3. Program Design Table in DPET Program

Goals	Measures: Indicators, and/or Benchmarks	Program Activities
Teachers become familiar with and can create a technology education curriculum in accordance with national standards	Journaling: Meaningful reflection on the curriculum Teacher-made curriculum: Teachers can create a high quality curriculum	Trainers facilitate discussion of the global, national, local (school) and individual curricula
Teachers gain knowledge of student-level evaluation of technology education	Teacher-made evaluation plans: Teachers can make or exhibit knowledge of valid and reliable measures of technology education	Trainers present evaluation strategies and technologies
Teachers can create activities in accordance with the curriculum	Teacher-made activity plan: Teachers have high quality activity plans (as rated by trainers)	Trainers present activities and technologies - for example, programming environments, robotics, etc.

2.7 Creating an Implementation Plan

The implementation plan concretizes how and when the different evaluation and program activities will be done. The appropriate method depends on the context and working history of the program designers. For

the DPET program, the designers found it helpful to fill out a matrix with chronological program activities in the columns and with labels for the people expected to carry out the different aspects of the program in the rows.

2.8 Creating a Reporting Plan

Sustainability of the program and evaluation use are strongly correlated with the success of reporting program activities and results (Torres, Preskill, & Piontek, 1996). Revisiting the stakeholder matrix and deciding on which, how, how often, and when each stakeholder group needs to be reported is a good strategy for creating a reporting plan. Although reporting is addressed in the plans for data collection and analysis, it is beneficial to have a separate reporting plan, that either complements or becomes a part of the implementation plan.

2.9 Implementation Evaluation

Implementation evaluation is important to verify that the program is being carried out as planned. As part of the DPET implementation evaluation, program designers made site visits to observe different aspects of program activities. Additionally, program designers were responsible for documenting and reporting the activities that occurred.

2.10 Data Collection, Analysis, and Reporting

After the data have been collected and analyzed, the results can be reported to the appropriate stakeholder groups according the reporting plan. Preskill and Torres (1999) suggest that evaluation use and the validity of conclusions drawn from the data can be increased by including stakeholders in the data collection, analysis, and reporting process.

2.11 Program Modification and Meta-Evaluation

Based on data collected from the evaluation, program designers may want to modify the program for a number of reasons. Since programs often have multi-year life spans, the modification and evaluation process should be thought of as an iterative process that occurs in cycles where each subsequent version of the program is an improvement on the last. Formal evaluation of outcomes usually is not appropriate until the program has had a chance to stabilize and mature. Programs go through developmental cycles and it is important to use the right kind of evaluation at the right time.

Meta-evaluation is a term that simply means evaluation of an evaluation. The goal of meta-evaluation is to make subsequent evaluation cycles better than the previous cycles. One method for conducting a meta-evaluation is to create meta-evaluation questions based around the *Guiding Principles for Evaluators* (American Evaluation Association, 2004).

3.   CONCLUSIONS

A detailed model for designing and evaluating teacher training programs in technology education was presented in this paper. It is not merely bound to its original context, but it can be applied to programs that are more general as well. Parts of the model are also useful in early program development. For example, the preliminary steps of the model are helpful in creating the plan for the program. Applying the plan throughout the program's lifespan helps standardize its activities, collect evaluation information, and develop the program through the continual analysis of evaluation data. It also allows the program's management to keep track of the program's progress. This model also serves as an explicitly stated road map for the program that helps practitioners know where they are heading at any given moment and what their tasks and duties are. It is also worth noting that the model is dynamic; the model itself can be improved and generalized to accommodate other units, treatments, outcomes, and settings through the practice of meta-evaluation.

In the DPET program, this model helped designers create an explicitly stated framework for the program's goals, activities and evaluation. It helped the program to become more manageable. Especially, the clearly stated goals and their respective measures were helpful both for the program itself and for the research activities related to it. The only downside of the model is its heaviness when using it for the first time. It takes a relatively long time to go through all the steps so the design team must be committed to their work in order to have the best possible outcomes.

4.   ACKNOWLEDGEMENTS

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Session 3

New Generation Technologies at School

THE PROJECT "LAB OF TOMORROW"

Designing and developing the school science laboratory of the future

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Abstract: The Lab of Tomorrow project introduces innovation both in pedagogy and technology. It aims at developing tools that allow for as many links as possible between teaching of natural sciences and every day life. Since science deals with the study of nature and the world around us, teaching science cannot be separated from daily experiences that result from student's interaction with the physical phenomena. In the Lab of Tomorrow project the re-engineering of the school lab of tomorrow is proposed along with the development of a new learning scheme based on the production of computational tools and project material that allow high-school students to use their every day life environment as the field where they conduct sophisticated experiments.

Key words: wearable devices; science education; sensors

1.   INTRODUCTION

There is sufficient evidence to suggest that both the persistence and the quality of learning are highly enhanced when the student is actively participating in the learning process. This is the essential and widely accepted message of "constructivism"[1] *(S. Papert, 1994, M. Resnick, 1993)* Juxtaposing this ideal with the current reality of organized learning in school environments creates the impression that the school is not connected at the desirable degree with daily life experiences.

One particular and most striking example is science teaching. Throughout history science has advanced through observation, inspection, formulation of hypotheses, testing of the hypotheses by means of experiments and collection of data, rejection or acceptance of the hypotheses, formulation of topics for further research. It seems that in schools this process of acquisition of scientific knowledge gets reversed. Science is presented as a coherent body of knowledge, the experiment is the illustration of the phenomenon, and the questions are answered even before they are asked. The result is that the student acquires short-term knowledge targeted at standardized test questions, and in many instances this "forced and inefficient" learning lacks on long term sustainability.

As it turns out the main link missing in the learning process is that students do not learn sufficiently through experience but through a systematic model based approach, which should be the culmination of learning efforts and not the initiation. A particularly disturbing phenomenon that is common knowledge among educators is that students fail to see the interconnections between closely linked phenomena in e.g. biology and chemistry, or fail to understand the links of their knowledge to everyday applications. In most cases the physical quantities have become abstract for the students and the experimental set-ups alien or distant to every day experience. Students are early faced with two separate fields: "school science" and every day life's "rules and principles".

2.   DESCRIPTION OF THE PROJECT

The **Lab of Tomorrow**[2] project is introducing innovation both in pedagogy and technology. It aims at developing tools that will allow for as many links of teaching of natural sciences as possible with every day life.

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[1] Also referred to the literature as constructionism (*E.v. Glasersfeld, 1995, R. Duit, 1995*).

[2] Lab of Tomorrow project is co-financed by the European Commision under the School of Tomorrow action line of the IST **5th** Framework Program (IST-2000-25076). The partnership

The Lab of Tomorrow project is developing a new learning scheme by introducing a technologically advanced approach for teaching science through every day activities. In the Lab of Tomorrow project the re-engineering of the school lab of tomorrow is proposed by developing a new learning scheme based on the production of computational tools and project materials that allow high-school students to use their every day life environment as the field where they will conduct sophisticated experiments experiencing the applicability of the theoretical background given at school. The connection of tangible phenomena and problems provides students with the ability to apply science everywhere and not only in specially designed experiments under the laboratory's controlled conditions *(D. Nachtigall, 1992).*
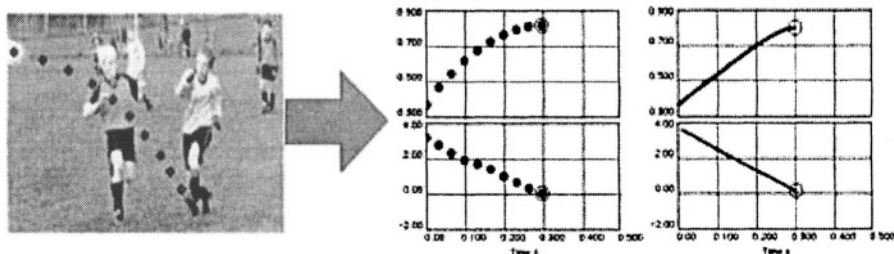
Figure 1. Lab of Tomorrow contributes to the connection of science teaching with every day life.

Within the framework of the project the partnership proceeds with the development of wearable technology, a series of "artefacts", called **axions,** which allow students to conduct sophisticated experiments and which, in many cases, involve data collection over extended periods of time. The axions embedded in toys or in clothes are used in order to collect data during students' activities. Important factors of their design are ergonomics and economy, so they will not stay on a test bench nor used by a small number of users. The data collected by the axions are presented with the use of advanced programming tools compatible with graphing and analysis software components so that students can easily investigate trends and patterns and correlate them with the theory taught at school.

3.   TECHNOLOGICAL INNOVATION

The trend of technology calls for smaller and smaller gadgets up to the point of the "disappearing computer", an ultimate goal of the proposed project that will build in ordinary items sensors and other measuring instruments and "disappear" them into clothes, toys and artefacts thus creating the "intelligent clothes" and "intelligent toys" all connected with a small wearable computer. By definition wearable computers will be used in environments, which differ dramatically from the normal domains of computer use. Wearable computers represent a new and exciting area for technology development, with a host of issues relating to display; power and processing design still to be resolved. Wearable computers also present a new challenge to the field of ergonomics; not only is the technology distinct, but with the manner in which the technology is to be used since the relationship between the user and computer has changed in a dramatic fashion.

Within the light of the above in Lab of Tomorrow, new wearable and embedded computer based technologies have been developed in order to foster the design of the new science laboratory of the school of tomorrow. Artefacts like a ball (Figure 2) that has a 3D accelerometer embedded represent innovative technological development of the project. A T-shirt (called sensvest) with several wearable sensors (Figure 2) is another state of the art educational toy.

The sensvest has embedded a heart pulse meter, a temperature sensor, a body accelerometer and an arm accelerometer some interconnected with embedded wiring and others wirelessly to a data local storage and communication board. All sensors can be used for the qualitative and quantitative study of several activities like walking, running, jumping or measuring the step rate for extended periods of time. In addition the senvest consists of a leg accelerometer module capable of measuring both the acceleration and the step rate of the leg for extended time periods. Leg acceleration data again transmitted wirelessly to the base station and the pc can be presented with information and data of the other toys in order to perform even more complicated experimental studies. As an example we can refer to the correlation of the acceleration data recorded by the axion ball and the leg accelerometer module aiming at comparing the forces exerted to the leg and the ball during a kick and thus used for studying the third Newton's law.
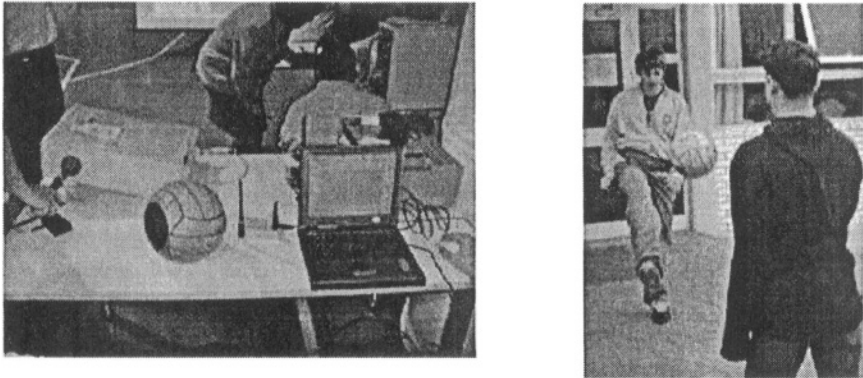
Figure 2. The axion ball shown on the table left transmits data wirelessly to the base station next to it. In the picture at the right the student wearing the sensvest kicks the ball.

In addition the senvest consists of a leg accelerometer module capable of measuring both the acceleration and the step rate of the leg for extended time periods. Leg acceleration data again transmitted wirelessly to the base station and the pc can be presented with information and data form the other toys in order to perform even more complicated experimental studies. As an example we can refer to the correlation of the acceleration data recorded by the axion ball and the leg accelerometer module aiming at comparing the forces exerted to the leg and the ball during a kick and thus used for studying the third Newton's law.

Finally a system called LPS (Local Positioning System) based on two CCD cameras is used for the location of 3D coordinates in space of selected objects with high accuracy. The two CCD cameras are situated in two orthogonal planes in space. The information deriving from the recorded images of the cameras combined with simple geometrical arguments (Figure 3) is used to calculate the position of the objects in space with a few centimetres accuracy. The LPS system can be used only inside the classroom as it is since the illumination conditions have to be controllable. Too much or too less sunlight might cause problems to the quality of the camera frame records.

A specialized software utilizes the information of the cameras and based on simple geometrical arguments allows for the determination of the three dimensional coordinates of selected objects. The data collected are synchronized, presented and analyzed with the use of a specially designed User Interface based on the concrete needs of the Lab of Tomorrow advanced teaching and learning "toys" and tools. Figure 3 illustrates two characteristic pictures that give a characteristic impression of the User Interface.
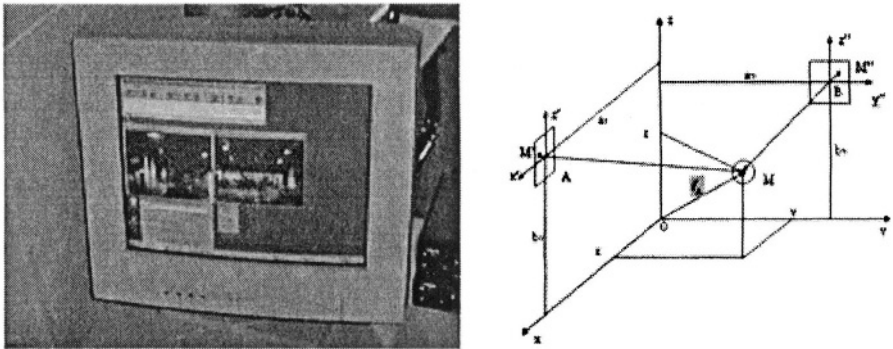
Figure 3. The LPS system is based on the combined use of the visual information of two CCD cameras that are situated in perpendicular planes.

The User Interface as the core node tool for an effective pedagogical use of the Lab of tomorrow systems is a very user friendly environment, easy to use even by novices and allows for many different ways of data representation and analysis. Students through a sequence of steps involving, data accessing, plotting data on a graph, creating a mathematical model to fit the data and relate the graph with the motions of the axions provided by the user-interface, gain deeper understanding of the phenomena. Moreover the user can easily export selected experimental data to other programmes like MS Excel or other specialized software for mathematical representation and analysis.
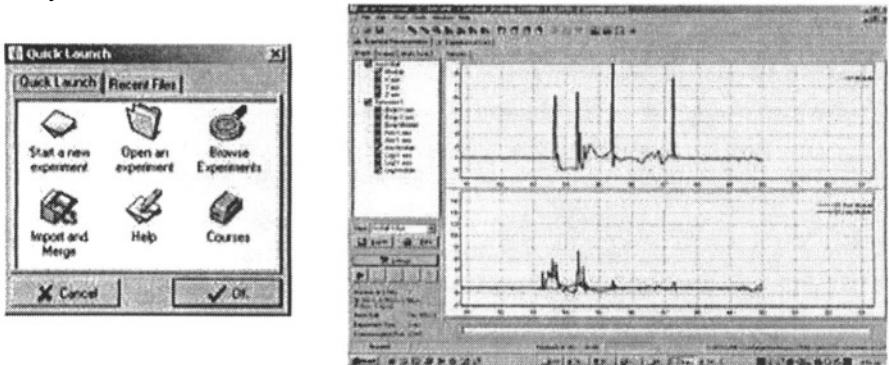
Figure 4. Aspects of the Lab of Tomorrow User Interface

4.   IMPLEMENTATION

Within the framework of the project, a user scenario-based design methodology is used as a means of defining suitable applications of wearable technology. A series of lesson-plans (scenarios) has been   developed. The lesson plans cover a wide spectrum of experimental activities and theoretical issues. Free fall, vertical throw, action and reaction or conservation of momentum experiments can be easily conducted with Lab of Tomorrow equipment. These lessons are implemented in the science curriculum of the participating schools[3] during the cycles of the school-centered work. The aim is to familiarize students and teachers with the new approach and toys as well as investigate possible qualitative upgrade of science teaching comparing with the conventional classroom lesson. The first school centered cycle was aiming at introducing students to the ideas and concepts of experimenting science lessons with Lab of Tomorrow. Moreover, during this cycle the developed toys were tested and evaluated in the different environments of the participating school and thus this cycle used to be called the test run phase. The conclusions derived by this phase formed the basis for the redesign of the axions and the determination of the implementation parameters for the successful application of the project's approach during the final run phases. The test run phase is followed by two other school centered working cycles, the final run phase A and the final run phase B. Currently the two final run phases of the project are in progress. In these two phases the new approach in science teaching is being systematically implemented and evaluated. To assure maximal usability of the new tools, optimal adaptation to the local environments and realistic evaluation of the pedagogical effects, the Lab of Tomorrow project utilizes a student-center approach that is expressed fully in final run phase B.

The final run phase A is based on the implementation of specially designed experimental lesson plans that are in accordance with schools' national educational curricula (Figure 5). The figures present aspects of the experimental and analysis activities during the "Horizontal Throw" experiment. The aim was to conduct experimental activities that were more or less included in the analytical programme of the schools but using the Lab of Tomorrow equipment instead. For instance students made the Free fall experiment with the use of both the axion ball and LPS system and analysed the data with the use of LOT User Interface. For the first time they had the chance, by viewing the data coming from the sensors embedded in the ball,

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[3] The pilot implementation school sites that are included in the partnership of the Lab of Tomorrow project are 5 secondary schools from Germany (Phoenix Gymnasium and Helene Lange Gymnasium both in Dortmund, BG & BRG Schwechat in Austria, Technical School of Pininfarina and Ellinogermaniki Agogi in Athens)

to "feel" what the ball "feels" when free falling. For the first time the students had the chance to investigate, in the three dimensions, the motion of the ball by analysing frame by frame the camera recordings of the LPS system. In this way the students have the opportunity to perform in depth study of motion and verify experimentally the theoretical mathematical and physical predictions presented in the school book. The use of LOT systems provide opportunities for insight study of many theoretical issues in physics and expand the capabilities of the science school laboratory much beyond its conventional limits.

This implementation of both phases A and B, is systematically monitored for evaluation purposes so as for the teachers to be able to record possible qualitative upgrade of their teaching performance and effectiveness.
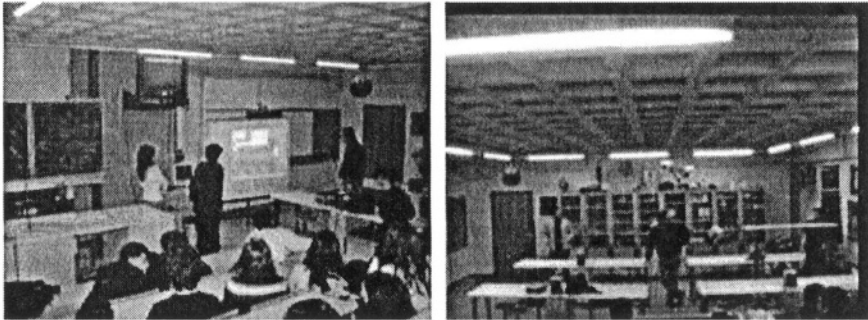
Figure 5. In final run phase A, students follow specific lesson plans based on the national curricula.

At the third school centered implementation cycle, the final run phase B, the students and teachers (having been used with the idea that scientific investigation is a process in which they can take part, day-to-day, creatively and pleasurably) have the opportunity to design their own scenarios for exploring phenomena of their everyday lives. The constructivist approach on Science teaching and learning becomes a reality and the students are taking an insight look of the connection of physics and science laws with their physical environment. These new experimentation ideas of the students will provide input for the development of new artifacts and the improvement of the Lab of Tomorrow prototypes.

5.   EVALUATION

The evaluation of the proposed didactic was initiated at the two last cycles of school centered work, namely the final run phases A and B

respectively. The evaluation of the project is evolving in parallel with the final run phases and it is performed on three aspects: evaluation of student's learning, evaluation of the underlying pedagogical framework and ethnographical evaluation.

- **Evaluation of the student's learning.** In assessing student's learning, student's engagement in science as inquiry will be primarily examined. It is believed that the activity of designing projects and experiments provides a powerful way for students to become meaningfully involved in scientific inquiry. In this way the dimension of self-expression will be introduced, something that is often missing in science education. Prompting students to see all sorts of daily activities, as possible subjects of both formal and informal scientific investigation will increase their motivation. Furthermore, this helps students on developing critical capacity and deeper understanding of the scientific concepts underlying the investigation. Finally students gain firsthand experience in the ways that technology can both serve and inspire scientific investigation.

- **Evaluation of the pedagogical framework.** The major theoretical issue underlying the Lab of Tomorrow project is whether the implementation of the emerging technologies (e.g. wearables) could offer a qualitative upgrade to the science teaching at the high school level. In such a case the introduction of technology would not act as a substitute of the conventional teaching but rather as an add-on that has to justify its introduction through the qualitative upgrade it offers to everyday school practice.

- **Ethnographic evaluation.** The project will take advantage of the different school environments across Europe and will study the attitudes of students and teachers with different cultures towards the implementation of IST in education as well as the attitudes between students themselves coming from different countries.

The evaluation design for the Lab of Tomorrow project's implementation in schools is organized as a semi-experimental. The main assessment tool is the "Third International Mathematics and Science Study" (TIMSS). For the Lab of Tomorrow project's evaluation scopes, performance and background tests in several grades are used. Both tests are suitable for the Lab of Tomorrow project's implementation, because their contents match with the content of the curricular of the participating countries and the content of the project. Secondly, Mathematics and Science items and test booklets are used for evaluation. These assessment tools have approved scales describing students' performance and they are available in different languages. The

experimental group consists of the Lab of Tomorrow classes in the participating schools while the control group is build up by classes that are taught in traditional way, but on the same topics as the experimental group.

6.   CONCLUSIONS AND FUTURE ACTIVITIES

Currently the project is about to complete its implementation phases (May 2004) and a six month evaluation and analysis period will follow. So far, the evidence of implementation in schools is very encouraging. Students are very positive with the new approach and Lab of Tomorrow project gives the opportunity for students to easily investigate a lot of new concepts experimentally with high accuracy and above all in a more experiential manner. New educational and technological aspects are investigated and put together in an open and exploratory fashion, encouraging educational innovations, within this project.

   Within the framework of the project the educational and technological aspects are investigated and worked on together in an open and exploratory fashion, encouraging innovation. The new ideas, concepts and technologies are tested and evaluated in relation to real school environments. In Lab of Tomorrow project students and teachers will come together with researchers, psychologists, designers and technologists to re-engineer the lab of the school of tomorrow. The aim is to help both teachers and students reach beyond "cliches" to the areas in which they can make the most valuable contributions, and potentially increase their role on the world stage afterwards.

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COLAB: A PLATFORM DESIGN FOR COLLABORATIVE LEARNING IN VIRTUAL LABORATORIES

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Abstract: Nowadays collaborative educational platforms are producing an important impact in our society showing this influence in a huge number of researching projects. The use of Information and Communication Technologies (ICT) has gained its prominence in the building of collaborative environments for educational purpose providing new ways of producing learning. So, in order to obtain an educational system which fits with the educational purposes, it is necessary to join pedagogical and technical efforts.

More concretely our developments are focused on Computer Supported Collaborative Learning (CSCL) systems, in which the ground of the knowledge building is the user collaboration. In this paper we are going to deal with the design and implementation of a platform for supporting collaborative learning using tools such as whiteboard, chat, posting tools, modeling experiments tools and other tools which allows view the results from the experiments.

Regarding the design of this platform it is has been used J2EE technologies for supporting the asynchronous communication and Elvin notification server like to support the synchronous communication.

In this paper it will be also described how it has been developed the architecture, showing as well how the tools can exchange events delivered in the communication channel. Finally, we will show an example of collaboration inside this system, and it will be explained how the user can move in this platform as well as how users can coordinate the use of some resources.

Key words: CSCL, Virtual Laboratories, J2EE, notification server

1.   INTRODUCTION

Nowadays collaborative educational   platforms are producing an important impact in our society showing this influence in a huge number of researching projects.   The use of Information and Communication Technologies (ICT) has gained its prominence in the building of collaborative environments providing new ways of producing learning.

Nowadays the University of Murcia (UM) is collaborating as an active member in several educational researching projects. More concretely it is involved in the European Project COLAB[6] "Collaborative Laboratories for Europe" (IST-2000-25035) whose main objective is the development of a CSCL[1,2] educational platform which allows user collaboration in order to solve and simulate some experiments. What is more, in this project the University of Murcia is responsible for defining and developing the architecture to support all the collaboration.

In order to obtain a CSCL system which fits with the educational necessities of teachers and students it is necessary to join technical and pedagogical effort. So, in the development of this project physicist, computer science engineers and educationist are working together to reach a desirable platform.

What is more this system does not pretend to replace traditional education way in fact it is shown as a system used to enrich the learning process encouraging students in the Physic subject through the use of the system.

In this paper we will deal with topics such as how it has been designed the COLAB system and the elements which are included in it, secondly it will be explained the log events caught in the system, after that it will be shown how users can interact with the system and finally it is exposed the conclusions and future work in this project.

2.   COLAB SYSTEM

2.1   Requirements

Following the pedagogical instructions all information in COLAB will be managed following this model:
1. All the users will be associated in groups.

2. Each group can access to some "Buildings". This term is introduced to group different phenomena (experiment simulators).
3. Each building consists of some "Floors", with the aim to offer some tools and simulators. Each floor implies different level of difficulty.
4. In each floor there are four "Rooms": Hall, Meeting, Theory and Laboratory. These rooms have specific meanings and different tools: Hall is the first room where users enter after they have been logged in a specific floor, Meeting is used for the communication, Theory includes all the tools for modeling experiments and Laboratory includes all the tools to manage phenomena, which are running on a remote server, and to show their status in client tools.

2.2   Colab Architecture

With the aim of obtaining an architecture which allows to store all the information in the educational platform the asynchronous part of this architecture is based on J2EE technology (Java 2 Enterprise Edition)[3] using JBOSS[4] server in our development. The main reasons for using this technology are the following:

1. The use of Entity Beans help in data base management.
2. The implementation of three layers model allows the separation between the interface, business methods and the database, facilitating the introduction of new applications in the platform.
3. Allow to develop portable code, so it can be run in any platform.
4. This technology is based on well-known standards which help in the system configuration and management.

However, this technology is not enough to solve synchronous collaboration between tools and users. For that reason, it was studied some technologies in order to obtain a synchronous model to support the synchronous collaboration. In our research we have studied the following technologies: JMS (Java Message Service), JSDT (Java Shared Data Toolkit) y DSTC Elvin[5]. Due to its high performance, efficiency and the good results in previous research [7,8], it has been selected the notification server DSTC Elvin as the core of the synchronous system. So it is responsible for managing all the events produced by the collaboration between different clients or by receiving events from remote laboratories or simulators. By specifying different building, floor and group the system will be able to established different sessions in which the distributed information is not mixed with the information generated in others sessions.

The JBOSS server stores all the COLAB structure, including the visual tools, which allows the collaboration between users and simulators, phenomena, users information, relations of groups, buildings, floors and rooms, as well as session files.

In the figure 1 is shown the general schema of the COLAB architecture. So all clients will establish a connection with the J2EE server in order to be introduced in the COLAB structure by selecting group, building and floor. In addition it will be established another connection with the Elvin US. Through this connection a client tool will be able to send and receive events to or from other clients or phenomena (sending events to start, stop the running of an experiment or receiving events with the results obtained in the experiment).
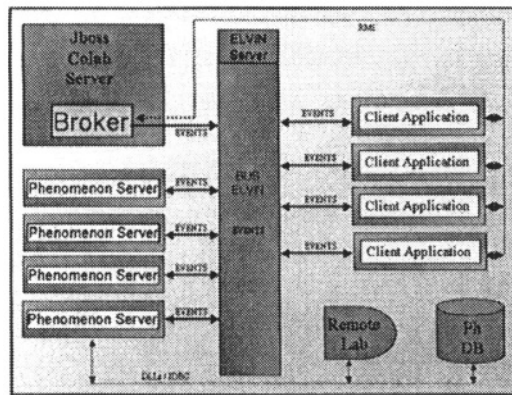
Figure 1. COLAB schema, reflecting the different elements like JBOSS, Elvin server, clients and Phenomenon server (simulators).

All the Visual Tools and the Phenomena are configured using XML files. In the configuration file it will be specified the variables and the values according to the corresponding tool or phenomenon. These xml files are stored in the JBOSS server.

With the aim of facilitating the management of Entity Beans it has been developed a SessionBean called broker which provides methods to create, delete, modify and retrieve all the instances in the database. Each client will establish a connection with a different Broker instance and using them, each client can retrieve all the information inside the JBOSS database.

In order to facilitate the development of new collaborative tools in the platform, it has been developed an API which allows to implement tools and phenomena avoiding to be conscious of how all the elements are related in

the system. Therefore, this API offers all the necessary interfaces to develop all the elements in the platform.

The Elvin Bus will be responsible for delivering information between tools, i.e. catching the data delivered by phenomena, allowing subscription to some parameters (in this way tools like graphs and tables can show the changes) as well as communication between users using the chat or the whiteboard. With the aim of helping in the data retrieval and transmission through the Elvin bus, it has been implemented the class "Environment". This entity will be responsible for delivering and retrieving information to the subscribed tools avoiding them to work directly with Elvin.
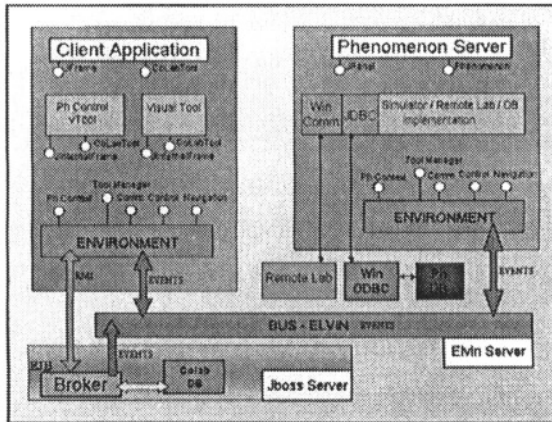
Figure 2. Environment functionality

What is more, all the programmed tools follows the same API offering a common set of methods by implementing an interface called "ColabTool". In this way, the "Environment" can communicate some events to tools invoking some methods from the interface. In order to run the tool in a dynamic way the system will execute the run method in each tool passing the "Environment" and the xml configuration for this tool. So tools will be able to use methods in the "Environment" to pass events to Elvin.

Similar to tools, phenomena will implement the interface "Phenomenon" and in this way they will manage a set of common methods which facilitate the communication through the "Environment".

2.3   Synchronous communication features

In order to maintain synchronous communication it is necessary to take into account the following features[9]:

1. Users in the same session manage the same information (Workspace Awareness)
2. All the resources in the system has to be accessed in a coordinate way which implies concurrency policies.
3. The user connection in the session will be possible at different points in the time. (Late Coming).
4. All the users need to be conscious of online users in their same session. (Presence Awareness)

To solve the first aspect all client tools are subscribed for receiving some events inside a session depending on the kind of tool, so all the users in a session can view the same information.

About the second point, it has been introduced the term of "leader" inside each room. So the first user who enters in a room will be the leader and the responsible for directing the activity progress in this room. This role can change during the collaboration because others users can ask about the control of the session. According to these requests the actual leader can give the control to anyone of them or well ignore these requests.

Furthermore, it is necessary to define a mechanism to establish critical sections which should be executed by only one user in order to obtain a coherent control in the change of some parameters. This mechanism will allow to synchronize the use of some sections and it will be modeled using a Token implementation, represented in our system like an EntityBean with grab and release methods.

So as to solve the late coming of users in rooms the leader will be the responsible for sending this information when he notices a new user has come into the room.

To cover the Presence Awareness feature, the application shows the members list in the left, lighting the online users and showing their location (room) in the session.

2.4   Dynamic phenomena management

In the COLAB system it can be held remote laboratories (hardware entities) and simulators (software entities). Both are represented like "Phenomenon" objects in the system, but they have different performance.

In the first case it would be required that only one group can manage it at a specific moment. In order to facilitate it, a reservation management has been designed indicating parameters such as date, hour and group to book the use of this phenomenon. On the other hand, it has been defined that simulators can be accessed by different groups at the same time, managing different information according to the group, building and floor where the session is held.

With the aim of facilitating the management of the phenomena servers, it has been built an application which is responsible for running and stop any experiment server for each actual session in a dynamic way. So, this tool is listening all the events of starting session and ending session from Elvin in order to run or stop the corresponding phenomena automatically. It also allows sending special messages to some floor, to stop and start specific phenomena as well as showing the progress of any running phenomenon in the system.
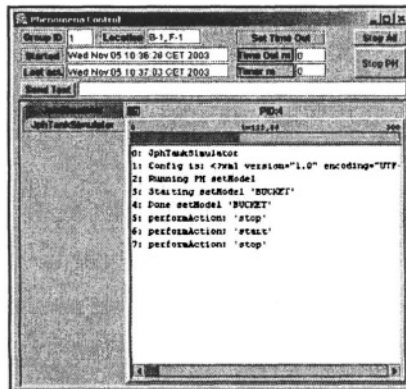
Figure 3. Phenomenon Control for the dynamic phenomena management

2.5   **Resources Manager**

In order to manage and relate all the information in the system it has been built an application which allows, among others tasks, to copy all the information in files as well as restore these files. This tool also provides ways to retrieve the XML information from tools status in a specific session as well as copy from one group to others so as long as they are in the same floor.

What is more, this tool help in the configuration of each "collaborative area" (building, floor, room) setting the necessary tools in the floor according to the purpose of this floor. In this way, the COLAB infrastructure provides several tools, and they can be assigned to different rooms in different floors.

Following the same pattern used for tools, it is possible to assign different phenomena to different floors according to the floor purpose. Both of these aspects give to the COLAB platform adaptability to needs of teachers and students.
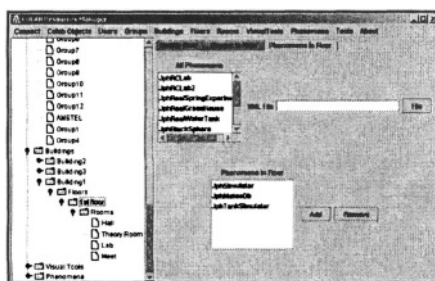
Figure 4. Resources Manager for managing all the data in COLAB

2.6   Colab Client

With the aim of granting that all users work with the same version in COLAB, the client design has been done using the Java Web Start technology. In this way an user will connect through a web page and by clicking a link the "Java Web Start" will be responsible for download the necessary jars for running the application and launch it. If the local machine have the latest jars the Java Web Starts will only launch the application.
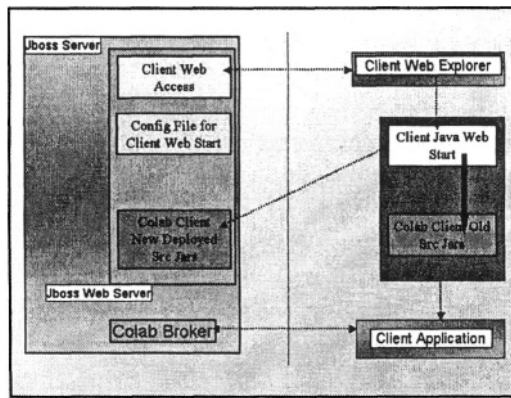
Figure 5. Client connection to Colab

2.7   Collaborative tools inside the system

One of the basis which help in the collaborative knowledge building are the tools used by the group for sharing the experiences of each participant. In this way the results from these interactions are the ground for the knowledge building process[2].

With the purpose of covering the previous aspect it has been implemented the following tools:

a) Chat.- This tool allow the textual communication between users and it is assigned to all rooms in order to facilitate this kind of communication wherever users are working. So users have the possibility of sending messages in a specific room or in all the rooms in the floor.

b) Whiteboard.- This is a tool for the graphical communication. It allows users to use different ways to represent their knowledge, using for example conceptual map to engage different items or to classify any concept.

c) Process Coordinator.- This posting tool help users to follow some goals added by teachers or by users in the same group.

d) Model Editor.- This graphical tool allows design simulations introducing different kind of elements and configuring them with values or parameters according to the group decision. It also provides options to execute this simulation and view the results through the graphics and table tools.

There are others tools which help in the learning process and are the basis for the discussion and the knowledge building of the group, such as

simulators, visual tools, graph and table tools and html viewer, which give general concept to students for starting to work in the collaborative area.

In order to continue working with data resulted from previous actions with other tools, there is a repository tool which stores the necessary objects to use them in other activities. In this way is possible to show values generated in previous simulations in the graph or table tools.

3.   LOG SYSTEM

In any CSCL system is really important to obtain the traces of the activity progress of users, their participation in the collaborative session and what are the concepts users has been dealing with.

In order to cover these analysis it is saved some events according to the pedagogical instruction. So each important action in each tool is caught and stored in a file. Due to the fact that tools have different behavior, different events will be saved in the different user/tool interaction. In the following figure it is shown some tools and special events generated in the interaction with the whole system.

Table 1. Some action events

Tool	Action
PC	Addgoal
	AddSubgoal
	ShowDescription
	ShowLinks
	ShowHints
	ShowNotes
	ShowHistory
	ShowReport
	ShowGoalTree
	CompleteGoal
	GoalName
	AddNote
General	Tools opening/closing
	LoginFloor#Building#
	LogoutFloor#Building#
	LeaveRoomMeeting
	LeaveRoomHall
	LeaveRoomTheory
	LeaveRoomLab
	EnterRoomHall
	EnterRoomMeeting

Tool	Action
	EnterRoomTheory
	EnterRoomLab
WhiteBoard	DrawShape
	MoveShape
	ResizeShape
	ChangeColor
	EditTextColor
ModelEditor	SelectOpenModel
	AddRelation
	DeleteRelation
	AddFlow
	DeleteFlow
	CheckSpecification
	RunModel
	OneStepRun
	StopModel
	ResetModel
Chat	Sendmsg
	SendToRoom
	SentToFloor

4.   EXAMPLE OF COLLABORATION WITH COLAB

Previously to a client connection, Elvin, Jboss and the Phenomena control must be running in the server. Firstly the user has to introduce his login and password and as soon as this data is validated the user can select the group, the building and floor where the session will be held. There is another way to connect by selecting an online user of the same group.

After that, the user will be located automatically in the "Hall" room. Once the user is in this room he can move to another room by clicking in the name (Hall, Meeting, Theory and Laboratory) shown in the left part in the application (see Figure 6). The user will be conscious of where he is because the corresponding room image will be light.
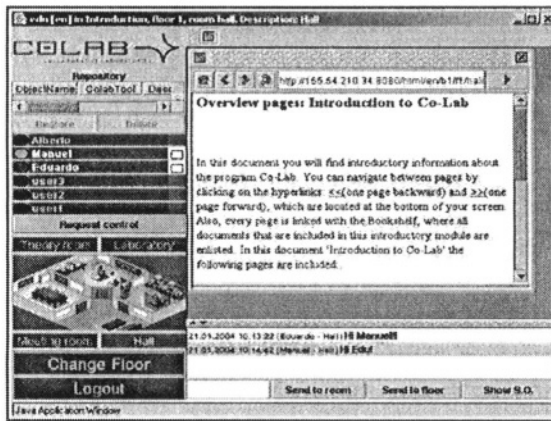
Figure 6. Hall Room

As it shown in the Figure 6 in the left part it appears the online users of this group, showing in which room they are located with an icon on the right of the name. A green circles marks who is the leader in a room, i.e. the person who controls the activity in this room. On the other hand, a red circle indicates users who are connected in the room and they are not leaders. Whenever one of these users want to became the leader he can ask for the control using the "Request control" button.

In the upper section of the application it is shown the tool bar and moving the mouse over an icon it a brief description of the tool is shown.
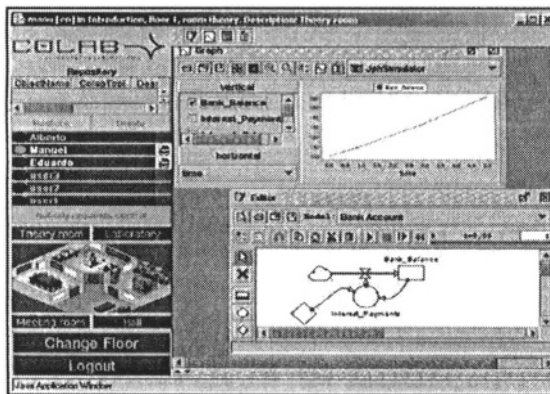
Figure 7. Theory Room
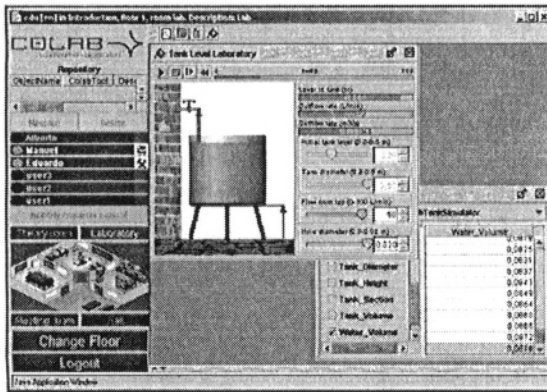
Figure 8. Laboratory Room

In the Figure 7 is shown the Theory room with the Model Editor to model and simulate experiments. In the Figure 8 is shown the Laboratory room with the JvtTankSimulator tool which caught the events from the corresponding phenomenon (TankSimulator) and shows them graphically.

Once the last user leaves the application all the work will be saved in the corresponding session of his groups, and so all the status of the tools can be retrieved in sessions subsequent.

5.   CONCLUSIONS AND FUTURE WORK

In this paper we have shown how it has been developed a platform for the collaborative learning by using virtual laboratories. So this platform held different collaboration areas where users can share their experiences and build new concepts or models by using tools such as whiteboard, chat, process coordinator and model editors. In this area the users are provided with several tools for obtaining experiments results, which will be the ground for the collaboration.

As a result of this architecture design and its components, it has been build an architecture which provides the *"basic ingredients for collaborative discovery: frames of reference, collaborative tools, and experimentation space"[2].*

In the development of this tool it has been built an architecture based on application servers in which the integration of new tools could be performed

easily. In addition, these tools could be assigned to different floors with different XML files, according to the use of this floor.

The system configuration is based on standards widely used such as XML, facilitating the configuration of each application using this standard.

Furthermore, this platform and its set of tools are shown to the final user like an application easy to manage, with intuitive graphical tools which can be managed in a friendly way for any kind of users. In this way we pretend to encourage users to learn Physic by the use of this system.

What is more it has been obtained a platform which is portable to any collaborative area. These features are obtained due to the fact that our development is based on the J2EE standard. In addition, the synchronous schema is valid for any kind of application because the subscriptions are performed by the tools and they are managed by the system using the "Environment" interface. For that reason, the whole design could be used in a different areas, such as working task, and other educational purposes.

In addition this system provides a way of catch and save important events from the collaboration in the system, and in this way teachers will be able to trace them by the use of tools which will be developed in next phases of the project.

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WEB-BASED COMPUTER VISUAL SIMULATOR
An Education Tool with Java Technologies

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Abstract: A visual simulator has been developed as an example of Web-based education tool, which is designed for students to understand graphically internal behavior and structure of computer system in a course of information engineering education. It is written in Java programming language, downloadable from Web server and executable on almost all types of personal computers including Java virtual machine and major Web browsers.

Key words: Web-based Education Tool, Visual Simulator, Java Applet, Built-in Mail Facility for Communication between Users, Trial Application to Collaborative Education

1.   INTRODUCTION

Recently, actual computers become higher-performance and more complicated. It is not easy for students to understand how computer works because of its complex black-box-like structure. An abstract lecture on computer cannot provide visual and applicable understanding on computer and assembly programming. In order to study computer more precisely, it is necessary to illustrate the internal behavior and structure of computer.

We have developed a visual simulator called "VisuSim" as Web-based education tool for computer system. It is implemented in Java programming language. With this tool, it is useful for students to understand visually the internal behavior and structure of computer. VisuSim provides window-

oriented graphical view to explain how computer works, for example, to interpret sample assembly programs and to illustrate data transfer mechanism between registers of CPU and memory. It has been designed to fulfill its function not only as stand-alone application on several platforms but also as Java applet on major browsers.

This paper describes the basic design concepts and existing facilities of our proposed visual simulator. It illustrates characteristics of its GUI for actual manipulation, explains simulating facilities with two kinds of execution modes, and demonstrates details of newly enhanced facilities such as on-line help guide and embedded mail handler. Finally, the application of VisuSim to practical lectures and current evaluation as Web-based education tool for computer system and/or assembly programming are also shown.

2.   DESIGN OF WEB-BASED EDUCATION TOOL

First of all, design concepts of our simulator "VisuSim" are summarized as follows [1]:

a) It is used as a practical education tool, which ranges from lectures of computer system to exercises of assembly programming. It illustrates internal behavior and structure of von Neumann-style computer;

b) It is equipped with a simple GUI for interactive manipulations which includes initialization, program loading, and execution of program. It simulates stepwise and/or continuous execution of programs and provides an effective environment for assembly program debugging;

c) It is implemented by means of a single source code in Java language which can be used not only as stand-alone application but as Java applet. It is easily distributed from Web server into users through network connectivity;

d) It is independent from the type of operating system and/or machine specification and is also available in multiple platform environments. It works on major Web browsers such as Microsoft IE and Netscape Composer/Navigator so that it does not need additional software.

Although many of these concepts are not original ideas for our simulator, they are efficient ideas for designing education tools and effective methods for utilizing tools in the practical situation. We know that simulation-based learning is one of the most efficient ways to educate student from university to elemental school [1][2]. There is the same idea to develop a visual simulator with Java for understanding behavior and structure of internal computer [3]. But it is our original approach to design visual simulator in order to work as both stand-alone and Java applet in order to be used in the

classroom lecture, after school, or at home. For example, VisuSim may be invoked as stand-alone application. In this case, it can read local files of sample programs and/or help message. In another case, VisuSim may be downloaded from Web server and be running as Java applet. It can obtain sample programs and/or help messages from its Web server and execute and/or displaying them on the browser. Figure 1 shows a scheme of both ways to utilize VisuSim.
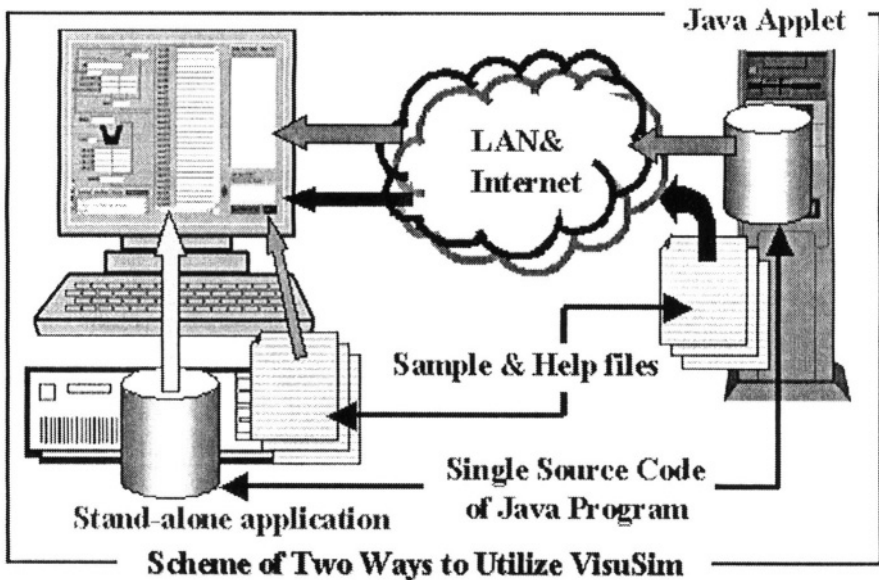

Figure1. Scheme of Both ways to utilize Education Tool: VisuSim

Secondly, the existing features of the simulator are illustrated on a practical example. With our visual simulator, it is graphically demonstrated how computer works, namely; loading program into memory; fetching each instruction of program in the memory; decoding it into several fields such as operation code and address fields; and executing accordingly to the result of decoding instructions.

Its on-line help mechanism is implemented to allow VisuSim to read a specific file and display its contents on the newly created window. Teachers can rewrite such a file in order to customize the help message of VisuSim for each student, and select suitable files of sample codes according to student's understanding level.

3.   CAPABILITY OF THE SIMULATOR VISUSIM

3.1   GUI of VisuSim and its simulation modes

A GUI of VisuSim plays two roles as follows; a) to provide information about simulated computer and b) to control the VisuSim. Figure 2 shows an applet-based GUI of VisuSim.
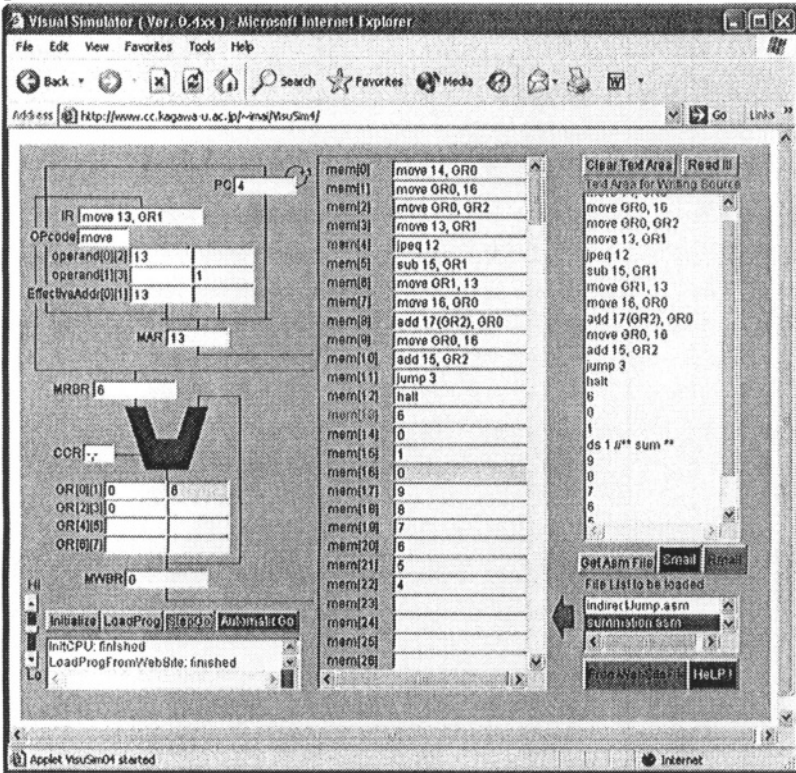
Figure2. GUI of VisuSim running on Applet

The former feature is constructed with several labels and text fields which configures corresponding registers in internal structure of computer. Control Unit including program counter (PC) and instruction register (IR) is allocated at the upper right hand of GUI. Processor including ALU and registers (GRs) is located below Control Unit. The middle position of GUI is for main memory, which is laid on sliding panel.

The latter feature of GUI consists of buttons and other objects for information interchanging between the simulator and user. Major four buttons are placed on the lower right hand of GUI, which are assigned for

initializing CPU, loading program to memory, executing program step-by-step, and executing autonomously, respectively.

It is indispensable to provide such a sufficient way that students can correctly use GUI including buttons, fields and so on. Display of guideline for users is effective and important in order to explain the purpose of each feature in the GUI and to indicate how to use it.

3.2   Two kinds of Simulation modes

VisuSim provides two different kinds of simulation modes: a step-by-step execution of program (called "stepwise mode") and a continuous execution (called "automatic mode"). The former is convenient for tracing the program step-by-step and finding illegal points of program, while the latter is helpful to execute a series of code blocks continuously in order to confirm whether a whole program works correctly or not.

Two kinds of simulation modes are summarized as follows;

(1) Stepwise mode execution:

When the button for "Step Go" is clicked, the internal simulator module of VisuSim activates only one machine cycle execution. A machine cycle of this mode strictly consists of instruction fetching, instruction decoding and execution. Sequential execution of the specific part of program needs consecutive operations of clicking the button for "Step Go". This simulation mode is suitable for interactive modification of registers and/or memory while breaking the execution. Namely, it is convenient to stop the execution of a program at any point, change contents of memory and/or CPU (including several registers), and then restart from such the previous break point. This mode could make VisuSim compute only the limited part in the long size code of program, if program counter is set to the specific location and the button for "Step Go" is being clicked during the suitable times. Such a process can point out the illegal description of programs, offer a better modification for improving, and finally prove code consistency of those examined programs. A detail testing of program can be realized in this mode. For example, it is useful to understand how a computer works.

(2) Automatic mode execution:

When the button for "Automatic Go" is clicked, the internal simulator of VisuSim starts continuous repetition of machine cycle execution until decoding halt instruction or occurrence of interruption. This mode is much useful for a relatively long-term demonstration where VisuSim must interpret a program including, for example, several iterations, recursive procedure calls or other kind of complicated processes. Because this mode of execution looks like playing slide show, it is helpful to trace a whole target program sequentially and verify whether the program is computed accurately

or not. While VisuSim repeats its machine cycles in the automatic execution mode, pushing the button for "Automatic Go" can trigger occurrence of interruption. At the interruption of VisuSim, pushing again such a button allows VisuSim to restart its machine cycles from the previous interrupted point. Speed control is available on a slide bar and can be varied from higher level to lower one. Each personal computer has various CPU with different type of frequency. It is useful to adjust the simulation speed of VisuSim in accordance with the different execution environments.

3.3   Communication with VisuSim's Mailing Facility

The mail handling facility embedded in VisuSim has been realized with pure Java code and consists of two major parts below, namely, SMTP-based mail sender module and POP3-based mail receiver one.
(1) Characteristics of SMTP-based mail sender:

This mail sender is different from other general-purpose mailers' sending modules at the following two points. At first, when students, who use VisuSim, meet some problems and want to consult teacher or friends about such a situation, they can simply transfer the current state of simulator in VisuSim (including data of all the registers and memory) into a mail to be sent. And moreover, by means of sending e-mail with the status of VisuSim, reports of students are easily submitted to teacher in the lecture of computer system and/or assembly programming exercise. Data in the content of the received mail can be analyzed in order to investigate whether student understands or not by teacher who received such a mail. This is a major reason to develop a special-purpose embedded mailer for VisuSim.

Secondly, when users want to write e-mail with SMTP-based mail sender of VisuSim, they may specify the e-mail address not only as domain-name oriented notation such as "imai@eng.kagawa-u.ac.jp" but also as IP address specific notation such as "imai@\#192.168.0.3". It is very useful for users to send e-mail with SMTP-based sender provided by VisuSim, because almost all temporary (informal) mail servers for users of VisuSim are not always entered on the official Domain Name Server and therefore such a mail server must be specified with IP address only.

As you know, there is still a problem for SMTP-based sender invoked from VisuSim which is running on Java applet. Such an applet is so tightly limited on network activity that it cannot access other servers except of the Web server which actually distributes VisuSim's applet code to user's browser. In order to improve such a case and realize communication by e-mail, the Web server will be also required to be equipped together with mail service facility in our system. In the case of VisuSim running as stand-alone application, however, users can be released from this restricted usage of

VisuSim. It is available for users of VisuSim to send their e-mail to any server they want by means of SMTP-based sender.

Figure 3 illustrates a scheme that SMTP-based mail sender performs sending e-mail, which is invoked from VisuSim running on applet.
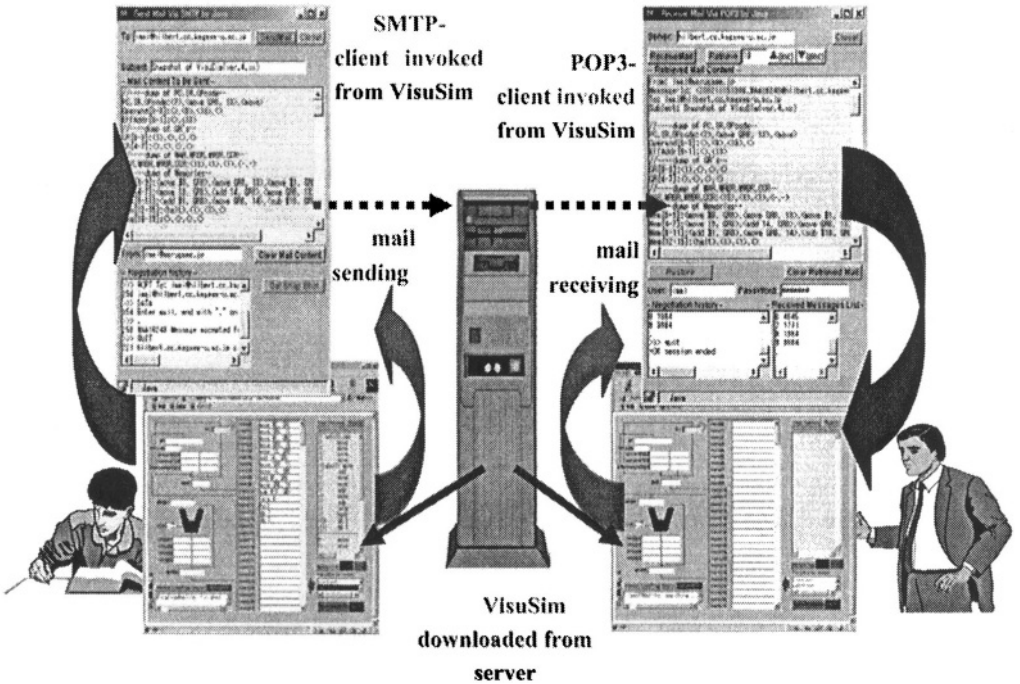

Figure 3. Overview of Collaborative (Distance) Education with VisuSim

(2) Characteristics of POP3-based mail receiver:

As the same functions of SMTP-based mail sender, this mail receiver has the following two characteristics different from others; namely easy restoring data of all the registers/memory in VisuSim from content of the received mail and IP address direct specification of mail server. On the other hand, it has some weaknesses to handle several kinds of mail messages. For example, it cannot process mail with attached files. Although it reads out the specified mail from server, it shall not delete that mail data from the server. So another mailer will be able to process non-deleted mails with attached files. The mail facility of VisuSim may be useful not only for consulting communication between students and teacher but also for on-line submission of students' reports to teacher. Figure 3 also shows such a communication between students and teacher. The mail sender and receiver of VisuSim can handle message in Japanese as well as English. With such embedded mail handler of VisuSim, students who need some kind of advice can send help mail to others and obtain suitable advices from teacher and/or other students

who know more than them. As a result, almost all students will benefit from submitting their reports to the teacher by means of the above mail service.

3.4   Function of Simulator

Structure of program is sometimes discussed in a lecture of computer system and assembly programming exercise. Program including iteration with index registers belongs to a class of difficult subject for beginner of computer. In general, iteration is implemented with combination of conditional jump, indirect addressing and so on. Beginners may suffer from lack of suitable education tools which support illustrating how relatively complicated iteration is processed in a computer. For example, it is useful to explain the concept of effective addressing in order to show the distinction between direct addressing, indirect one and immediate value one graphically. Explanation of mechanism for subroutine call and return is one of the most essential themes in the computer system. It must involve calling sequence with parameter passing and allocation of stack and/or heap. Recursive subroutine call may be frequently included in the above themes. As stack frame is easily handled by a few suitable instructions, recursive programs can be written at assembly programming level. It is very important for students to be given a graphical explanation of the internal behaviour and structure of computer, for example, how stack area grows and reduces.

Assembly programming exercise is available through an effective application of our visual simulator as well as it is used to illustrate the internal behaviour and structure of computer. Therefore, relatively complicated iteration processing can be realized with such addressing and interpreted by VisuSim. It is one of the important characteristics that the detail of programming techniques may be explained, which could be hardly understood with only high-level programming languages, such as parameter passing between subroutines and manipulation of data structure and/or array. It is effective that the detail of programming techniques may be explained, which could be hardly understood with only high-level programming languages.

4.   APPLICATION OF VISUSIM

This sections shows actual cases of using our visual simulator, VisuSim.
(1) Actual Lecture of Computer System
In the classroom lecture such as Computer System and Information Literacy, utilization of VisuSim can advance students' interest in the internal behavior and structure of computer system. Based on sample programs, each

student challenges to write assembly program and investigate how it is processed inside a computer. With VisuSim as visual education tool, it is available for beginners to understand visually several mechanisms that many kinds of program are processed in computer. It is more effective to educate how computer works by means of VisuSim than by lecture with abstractive explanations. Figure 4 shows actual lecture of Computer System with display projection of VisuSim onto a large screen.
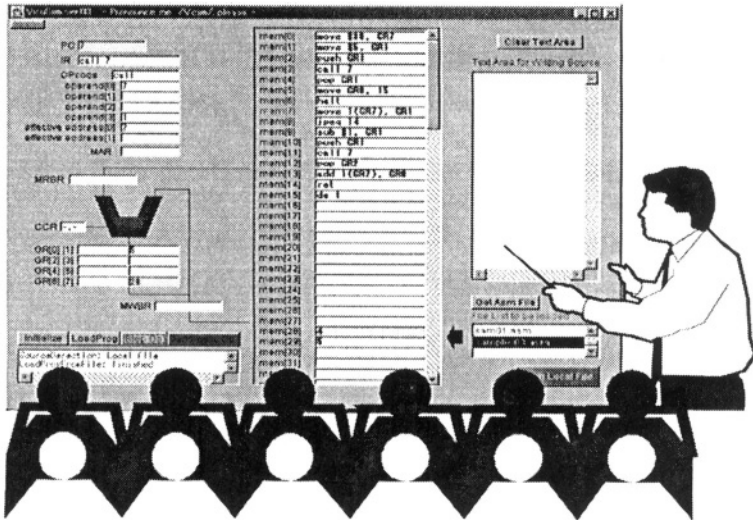

Figure 4. Image of Lecture using VisuSim

(2) Application to Assembly Programming Exercise

Assembly programming capability is essential for education of information systems engineering. This capability can be obtained from not only by lecture on computer system but also by practical exercise. From our Web server, users can obtain other examples of assembly programming such as selection with several conditional jump instructions, repetition with indexed addressing, and so on. Recursive call is one of typical medium-level themes about assembly programming. For example, calculation of factorial and resolution of Hanoi's tower are suitable themes for beginners' learning recursion. Because stack-related instructions are equipped, VisuSim can provide a simple assembly-programming environment to describe recursive subroutine call.

Consequently, combination of two execution modes will provide a powerful debugging facility. In the class of assembly programming exercise, for example, such a debugging facility has been employed to verify whether programs work correctly or not. It is also effective to explain the correspondence between description of high-level language and the

behaviour of computer such as numbers of repetition and the content of loop control variable in the specific general-purpose register.

5.   CONCLUSION

The system configuration and some applications of our visual simulator, VisuSim are introduced in the paper. We can conclude our study as follows:

a) By use of VisuSim, a graphical demonstration is available in classroom lecture on Computer System and Assembly Programming, so that it is easy and transparent for even beginners to understand the internal behavior and structure of computer more precisely;

b) Help messages and suitable sample programs can be obtained from a Web server. Embedded mail handler can be provided for communication between its users. It is useful for students to practice with VisuSim not only in the classroom lecture but also after school and/or at home;

c) VisuSim can provide an environment for distant learning for assembly programming. And we may possibly apply VisuSim to an actual example of collaborative learning.

ACKNOWLEDGEMENTS

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COMPUTER SUPPORTED UBIQUITOUS LEARNING ENVIRONMENT FOR VOCABULARY LEARNING USING RFID TAGS

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Abstract: This paper describes a computer-assisted language learning (CALL) in a ubiquitous computing environment. The environment, called TANGO (Tag Added learNinG Objects) system, detects the objects around the learner using RFID (Radio Frequency Identification) tags, and provides the learner the right information for language learning. This system supports learning in daily life with PDA (personal digital assistant) beyond web based education with desktop computers. In the experiment, the learner played the game of TANGO, and was very interested in this system.

Keywords: Computer Supported Ubiquitous Learning, Mobile Learning, Pervasive Learning, Computer Assisted Language Learning, Vocabulary Learning, and RFID tag.

1.   INTRODUCTION

Ubiquitous computing [1] will help organize and mediate social interactions wherever and whenever these situations might occur [6]. Its evolution has recently been accelerated by improved wireless telecommunications capabilities, open networks, continued increases in computing power, improved battery technology, and the emergence of flexible software architectures. With those technologies, an individual learning environment can be embedded in the real everyday life.

The main characteristics of ubiquitous learning are shown as follows [3,4]:

a) Permanency: Learners never lose their work unless it is purposefully deleted. In addition, all the learning processes are recorded continuously everyday.

b) Accessibility: Learners have access to their documents, data, or videos from anywhere. That information is provided based on their requests. Therefore, the learning involved is self-directed.

c) Immediacy: Wherever learners are, they can get any information immediately. Thus, learners can solve problems quickly. Otherwise, the learner can record the questions and look for the answer later.

d) Interactivity: Learners can interact with experts, teachers, or peers in the form of synchronous or asynchronous communication. Hence, the experts are more reachable and the knowledge becomes more available.

e) Situating of instructional activities: The learning could be embedded in our daily life. The problems encountered as well as the knowledge required are all presented in their natural and authentic forms. This helps learners notice the features of problem situations that make particular actions relevant.

Moreover, ubiquitous learning can be Computer Supported Collaborative Learning (CSCL) [10] environments that focus on the socio-cognitive process of social knowledge building and sharing.

The challenge in an information-rich world is not only to make information available to people at any time, at any place, and in any form, but specifically to say the right thing at the right time in the right way [5]. A ubiquitous computing environment enables people to learn at any time and any place. But the fundamental issue is how to provide learners with the right information at the right time in the right way. This paper tackles the issues of right time and right place learning (RTRPL) in a ubiquitous computing environment.

This paper proposes TANGO (Tag Added learNinG Objects) System for vocabulary learning. At the beginner's class of language learning, a label that has written the name of the object is stuck on the corresponding object in a room in order to remind learners the word. The idea of this system is that the learner sticks RFID (Radio Frequency Identification) tags on real objects instead of sticky labels, annotate them (e.g., questions and answers), and share them among others. The tags bridge authentic objects and their information in the virtual world. TANGO system detects the objects around the learner using RFID tags, and provides the learner with the right information in that context.

The motivation of this research is based on the first author's experience. As a visiting researcher, he visited the center for lifelong learning and design at the University of Colorado at Boulder in USA for 18 months. Before staying USA, he had learnt English (mainly reading and writing skills using text book) for almost 20 years from junior high school. However, he had a lot of difficulties in the daily life in USA because of the difference between English he had learnt and English in the real world. This means it is necessary not only to learn English with text book, but also to learn it in the real situation. Therefore, in order to solve this problem, this paper proposes computer supported ubiquitous learning for supporting learning in the real

world. The system facilitates sharing the past experiences, presenting the right question at the right place and the right time by detecting the context of the learning situation, and solving the confront problem immediately by providing the right information via wireless network.

2. CSUL: COMPUTER SUPPORTED UBIQUITOUS LEARNING

2.1 What is CSUL?

CSUL (Computer Supported Ubiquitous Learning) is defined as a ubiquitous learning environment that is supported by embedded and invisible computers in everyday life. Figure 1 shows the comparison of four learning environments according to [6]. The CAL (computer assisted learning) systems using desktop computers are not embedded in the real world, and are difficult to move. Therefore, those systems hardly support learning at anytime and anywhere.

Compared with desktop computer assisted learning, mobile learning is fundamentally about increasing learners' capability to physically move their own learning environment with them. Mobile learning is implemented with lightweight devices such as PDA (Personal Digital Assistant), cellular mobile phones, and so on. Those mobile devices can connect to Internet with wireless communication technologies, and enable the learning at anytime and anywhere. In this situation, however, computers are not embedded in the learner's surrounding environment, and they cannot seamlessly and flexibly obtain information about the context of his/her learning.

In pervasive learning, computers can obtain information about the context of learning from the learning environment where small devices such as sensors, pads, badges, and so on, are embedded and communicate mutually. Pervasive learning environments can be built either by embedding models of a specific environment into dedicated computers, or by building generic capabilities using computers to inquire, detect, explore, and dynamically build models of the environments. However, this makes availability and usefulness of pervasive learning limited and highly localized.

Finally, ubiquitous learning has integrated high mobility with pervasive learning environments. While the learner is moving with his/her mobile device, the system dynamically supports his/her learning by communicating with embedded computers in the environment. As for the broad definition of ubiquitous learning, both pervasive learning and mobile learning would be in

the category of ubiquitous learning. RFID tags are often used to realize pervasive computing.
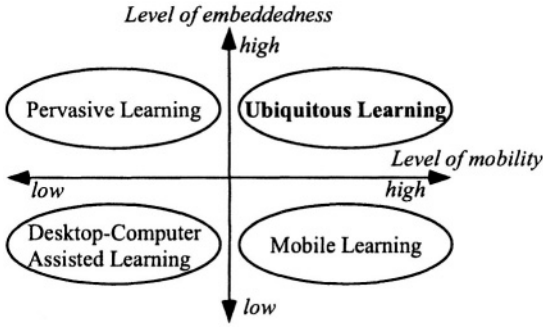

Figure 1. Classification of learning environment. (based on [6]).

2.2   Learning Theories for CSUL

CSUL is advocated by pedagogical theories such as on-demand learning, hands-on or minds-on learning, and authentic learning [8,9,10,11]. CSUL system provides learners on-demand information such as advices from teachers or experts at the spot at the precise moment they want to know something. Brown, Collins, and Duguid [2] define authentic learning as coherent, meaningful, and purposeful activities. When the classroom activities are related to the real world, students receive great academic delights. There are four types of learning to ensure authentic learning: action, situated, incidental, and experimental learning [13].

Miller and Gildea [7] worked on vocabulary teaching, and described how children are taught words from dictionary definitions and a few exemplary sentences. They have compared this method with the way vocabulary is normally learned outside school. People generally learn words in the context of ordinary communication. Therefore, we believe that it is very important to support vocabulary learning in everyday life with ubiquitous computing technologies.

3.   TANGO

We have developed the prototype system called TANGO, which works on a Toshiba Genio-e with Pocket PC 2002, RFID tag reader/writer (OMRON V720S-HMF01), and wireless LAN (IEEE 802.11b). RFID tag reader/writer is attached on a CF (Compact Flash) card slot of PDA as shown in Figure 2.

The tag unit can read and write data into and from RFID tags within 5 cm distance, and it works with a wireless LAN at the same time. The TANGO program has been implemented with Embedded Visual Basic 3.0.
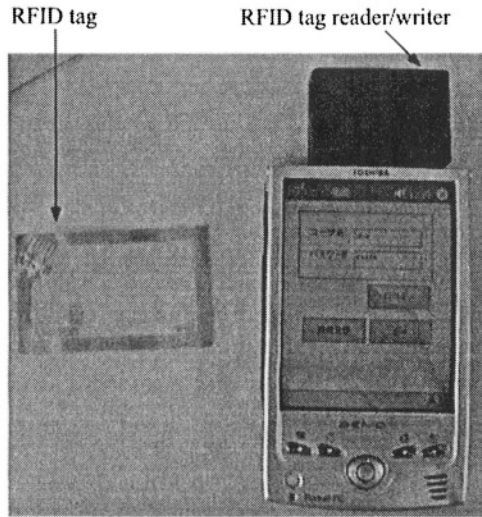

Figure 2. TANGO system.

3.1 RFID

Radio frequency identification (RFID) tag is a rewritable IC memory with non-contact communication facility. There are two organizations for promoting this technology.

First, the Auto-ID Center [14] is "designing, building, testing and deploying a global infrastructure - a layer on top of the Internet - that will make it possible for computers to identify any object anywhere in the world instantly. This network will not just provide the means to feed reliable, accurate, real-time information into existing business applications; it will usher into a whole new era of innovation and opportunity."

Second, the Ubiquitous ID Center [15] "aims to establish and spread core technology to automatically recognize "things", and eventually realize a ubiquitous computing environment." This paper presumes objects in the real world have ID tags, and computers can easily identify them.

3.2 System Configuration

TANGO has the following modules:
a) Learner model: This module has the learner's profile such as name, age, gender, occupation, interests, etc, and the comprehensive level of each

word or each expression about an object. Before using TANGO, the learner does the examination, and enters the comprehensive level. In addition to this explicit method, TANGO detects learner's comprehension during the system use.

b) Environmental model: This module has the data of objects, rooms and buildings, and the link between objects and expressions in the learning materials database.

c) Educational model: This module manages words and expressions as learning materials. The teacher enters the fundamental expressions for each object. Then, both learners and teacher can add or modify them during system use.

d) Communication tool: This tool provides the users with a BBS (bulletin board system) and a chat tool, and stores their logs into a database.

e) Tag reader/writer: This module reads the ID from a RFID tag attached to an object. Referring to the ID in the object database, the system obtains the name of the object.

f) User interface: This module provides learner questions and answers.
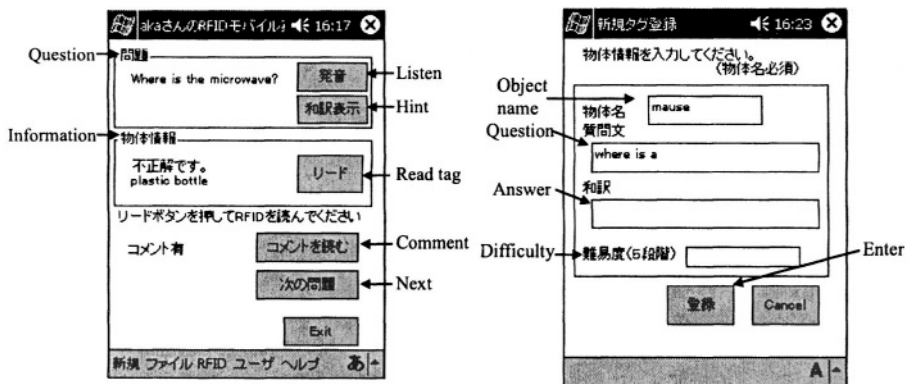
Figure 3. Main window and new-tag window of TANGO.

3.3   User Interface

The interface of the learning environment TANGO is shown in Figure 3 and 4. In figure 3, TANGO system asks the learner a question with voice. The adequate question is selected by scanning the RFID tags around the learner and using the learner model. If the learner cannot understand the question, the learner can listen again by clicking the button. Furthermore, if the learner cannot understand the question, the system shows the text of the question as a hit by clicking "hint button." By clicking "read button", the system begins to read a tag. If the learner scans the correct tag, the answer is

right. Then, the learner can move to the next question by pushing "next button." If the object has a comment, the comment button is active. By clicking "comment button", the comment appears as shown in figure 5. The learner can also add comment by clicking "add comment" button (see in figure 6). The learner has RFID tags, can attach them on objects, and create a new question about the new object as shown in figure 4. In this way, learners can collaboratively learn language by sharing comments and tags.
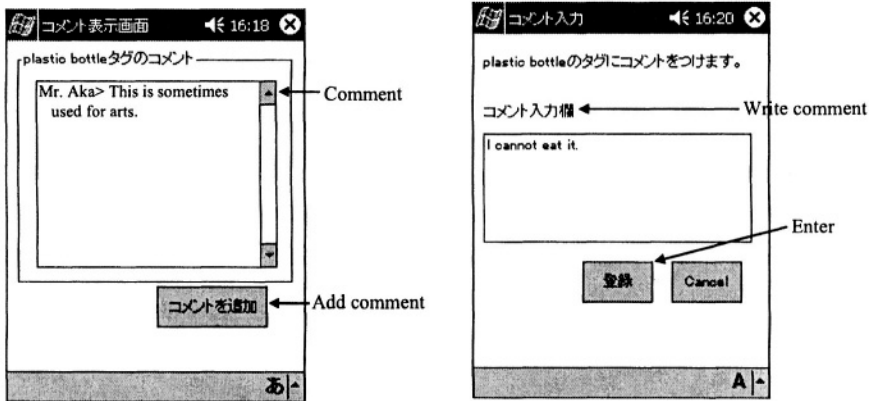

Figure 4. Comment window of TANGO.
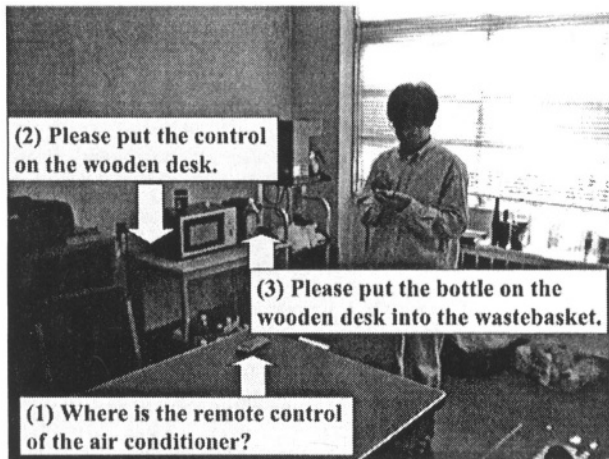
Figure 5. Usage example of TANGO.

Figure 5 shows an example of a room where RFID tags were attached to some objects for TANGO. For example, when the learner enters a meeting room, the system asks him/her the question "Where the remote control of the air conditioner is?". The learner can hear the question again if s/he wants. Moreover, the learner can see the text and hints. If the learner scans the tag labeled on the remote control, the answer is correct. Then the system will ask to put it on the wooden desk. This way, the interaction between the learner and the system goes on.

Table 1: The results of questionnaires.

No.	Questionnaire	Ave.	S.D.
Q1	Were the questions provided by this system difficult?	3.33	0.52
Q2	Do you think this system easy to use?	3.33	1.03
Q3	Do you think this system useful for language learning?	4.17	0.41
Q4	Is the response of this system is adequate to use?	3.67	0.52
Q5	Do you think this system very interesting?	4.33	0.52
Q6	Do you want to keep using this system?	3.83	0.75

4.   EXPERIMENTATION

We arranged six high school students to evaluate TANGO with a questionnaire. The average of the users' age was 16. The users had no PDA, and 50 percent of them had their own computers. We explained them how to use the PDA, before they used TANGO. Each user looked for objects in the room according to the questions read aloud by the PDA. For example, if the question was where the fabric chair was in the room, and. the user scans the RFID tag of the chair, the user gets the point. Otherwise, the user loses the point. Users competed against each other for getting the points. After the experiment, they gave a score between one and five to each of nine questions, with one being the lowest, and five being the highest. The average score was 3.78. Table 1 shows the results of the questionnaire. According to question (1), some of the users felt that the questions were difficult. Question (2) shows that TANGO system is not so easy to use. That is because this experiment was the first time for all the users to use a PDA. However, the user interface should be improved for the novice user who does not have her/his own PDA.

In terms of language learning, question (3) shows that TANGO was quite useful for it. One of the learners commented that with this system, it was easy to understand the terms by their correspondence with authentic objects.

From the results of question (4), we should make the response of the system a little faster. The questions (5) and (6) show the users were very interested in this system, and that they would like to keep using it. Some learners commented that they had a feeling of achievement.

5. CONCLUSIONS

This paper described a computer-assisted language learning (CALL) in an ubiquitous computing environment. TANGO system detects the objects around the learner using RFID tags, and provides the learner with the educational information. In the experiment, the learner played the game of TANGO, and was very interested in this system.

ACKNOWLEDGEMENT

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Session 4

E-Laboratories Experiments

USER ADAPTATION IN E-LEARNING ENVIRONMENTS

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Abstract: In this paper we present a distance-learning scheme that performs dynamic user evaluation in order to allow training of users adaptable to their needs. The appropriate learner profile is selected on-line, influencing the level and the contents of the offered courses while behavioral evaluation affects the pace of training and the way information is presented to the user. Learner profiles are created and continuously updated through an e-survey tool that is integrated into the system. In its current form the presented system aims at increasing the familiarity with ICT of teachers working in the Special Education sector.

Key words: user adaptable system, e-learning, e-survey, ICT level estimation, ICT statistics

1. INTRODUCTION

The impact of Information and Communication Technologies (ICT) has become more and more evident in learning and teaching at all levels of education. An ICT-based distance learning system consists of a set of electronic tutorials, information and tools which provide their users with enriched capability of accessing relative information.

However, existing e-learning systems, usually being of a self study nature, are not suitable for learners that do not already possess some knowledge about the topic that interests them. For such learners, the interaction with a real life teacher remains indispensable; automated on-line systems that are able to offer learning material modulated to the learning needs of every individual are, therefore, of great importance in modern ICT-based environment.

In this paper we make an attempt to narrow this difficulty. Specifically, we use the IEEE Learning Technology Systems Architecture [1] and develop an e-learning system that is able to adapt its operation to the learning needs of its users.

Our approach is based on the usage of electronic questionnaires (e-questionnaires) that are designed by a group of experts and aim to detect the user's cognitive level and learning preferences prior to the learning experience. Through analysis of their responses to the e-questionnaires, users can be assigned to corresponding profiles, and be consequently provided with learning material that best matches their needs.

As a case study, the proposed system in this paper has been utilized in the framework of "SPERO: A TeleInformatics System for Continuous Collection, Processing, Diffusion of Material for Teacher Training in Special Education", a European project [2] for the tuition of teachers, mainly of the field of special education, in Information and Computer Technologies (ICT) related topics. For this purpose, information concerning the ICT level of teachers has been collected through a pan-European survey; analysis of it has been performed and the main conclusions have been included in the initial form of an e-questionnaire.

The structure of the paper is as follows: in Section 2 we briefly present the general architecture of our system. In Section 3 we explain the adaptation of IEEE LTSA model and its usage in our system. Continuing, in section 4, we describe the design and structure of the e-questionnaires. Moreover, in section 5, we explain how an e-survey can be conducted. Section 6 describes how the e-questionnaires may be utilized towards the generation of user adaptable e-learning systems. Sections 7 and 8 illustrate the mechanism of the selection of e-courses and present a test bed environment for e-courses. In Section 9 we list our concluding remarks and future work plans.

2.   SYSTEM'S ARCHITECTURE

The proposed system is an e-learning system which can be adapted to the user's profile and interests. The main goal of this system is the characterization of the ICT level of users and its matching to the appropriate learning material and e-courses that will help them to improve their ICT level. In our study case, users are teachers who are called to answer a set of e-questionnaires. After completing of the questionnaires, teachers' profiles will be adapted to the system and then they will receive a set of e-lessons for improving their ICT level. Our aim is to propose a system architecture that can form a general architecture for an e-learning schema.
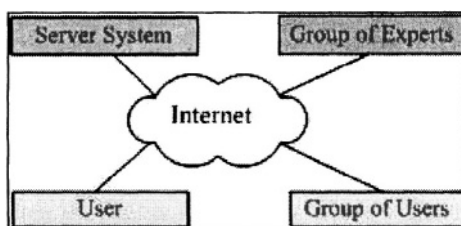
Figure 1. System architecture

The components that compose the general architecture (Figure 1) of the proposed system are the following:

Group of Users: in our study case, the group of users includes teachers who are working in any sector of education (general or special education). In an overview of our system's architecture, learners can include any student, teacher, parent, researcher, or employee. For this reason an adaptation of e-questionnaires to the users' needs is necessary.

Group of Experts: includes a variety of people, such as teachers, teachers of the Special Education sector, experts in e-learning, data analysts, psychologists and software engineers.

Server's System: includes the hardware and software that is suitable for the activation of a web-server. This system also includes web applications, such as e-questionnaires, e-survey and e-courses together with an RDBMS system.

Interaction between the components of the system can be achieved through the Internet using the proper equipment. To implement this architecture, the following steps have been followed.

Firstly, the group of experts investigated and analyzed the needs of the group of users. Then the experts defined the learning resources and design a group of questionnaires from which the users' profiles for this particular group of users can be extracted.

Subsequently, the software engineers have created an e-questionnaire database that is being updated with entries (texts of the questionnaires). The proper software has been developed for automatic retrieval and presentation of the questionnaires from the e-questionnaire database. The proposed software supports multilingual questionnaires.
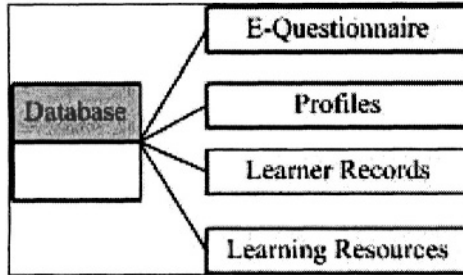

Figure 2. Database content

Additionally, software for automatic survey conduction based on users' answers has been developed. Conclusions derived out of the e-surveys, as well as feedback from the use of the e-questionnaires, are fed back to the e-questionnaires. User's profile categorizations are automatically extracted by the system, which takes as inputs the answers of users stored in user records. More than one learning resources (e-courses, multimedia databases including educational TV programmes, newspapers' files, TV files) are selected by the experts, for each distinct collaborative user profile.

3. A REFINED IEEE E-LEARNING MODEL

The proposed system's architecture is based on the IEEE Reference Model [1]. This standard specifies a high level architecture for e-learning systems and describes the conceptual design and the generic components of these systems. The LTSA system is separated into three main categories (Figure 3): the Processes (oval shapes), the Store (orthogonal parallelograms) and the Flows (vectors).

The 'processes' category contains entities like learner, evaluation, coach and delivery. The 'stores' category includes databases in which learner records and learning resources have been stored. The interaction between learner and system is controlled by 'flows' which can be the learning preferences, the behaviour,the assessment information, the performance and the preference information,the query, the catalog info, the locator, the learning content and the multimedia resources.
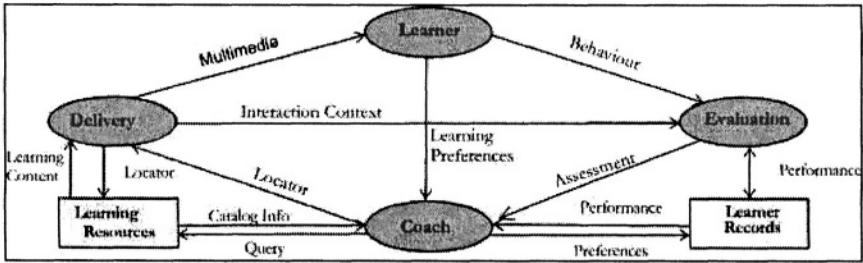
Figure 3. LTSA System Components

The main entity of the IEEE LTSA system is the Learner. A learner can be a single learner or a group of learners with different needs. Firstly, the learners receive an interactive framework, e.g. multimedia presentation; while the presentation is shown to the learners, their behaviours (e.g. responses to questions) are observed. This feedback brings data to the learner in order to enhance the learning profile of the learner.

The learning preferences are combined with the coach process, based on the language and cultural adaptation, as well as accessibility for people with physical limitations. The behaviour component, on the other hand, provides information about the learner's activities; this information (as keyboard clicks, mouse clicks, etc) is recorded in real time and used to evaluate the results of learning.

The evaluation process takes as input the learner entity's observable behaviour; the interaction context is the data flow from the delivery component to the evaluation component that may provide the necessary information for interpreting the information contained in the behavioural data flow. The evaluation component produces assessment information which is sent to the coach and creates performance information that is stored in the learner records. Performance information may come from both the evaluation process (e.g., grades on lessons) and the coach (e.g., certifications). The coach may receive performance information from the learner records at any time. Performance information, such as assessment information and certifications, as well as preferences may be stored in the learner records by the coach.

Based on this information, the coach generates queries and forwards them to the learning resources store, in order to request learning materials that are appropriate for each learner. The learning resources store is a database that represents knowledge, information, and other resources used in the learning experiences. It may be represented as a collection of presentations, tutorials, experiments, lessons, etc. The learning resources store replies to the coach with catalogue info, i.e. with a list of locators that

match the search query. These may be used by the delivery process to retrieve learning content.

Finally, the delivery process transforms information obtained via learning content into a presentation, which is transferred to the learner entity via a multimedia stream. In the LTSA Draft Standard, a system's ability to adapt its operation to the learner is not obvious; although an evaluation process exists, the way via which this process can be utilized to allow for learner adapted operation is not clear.
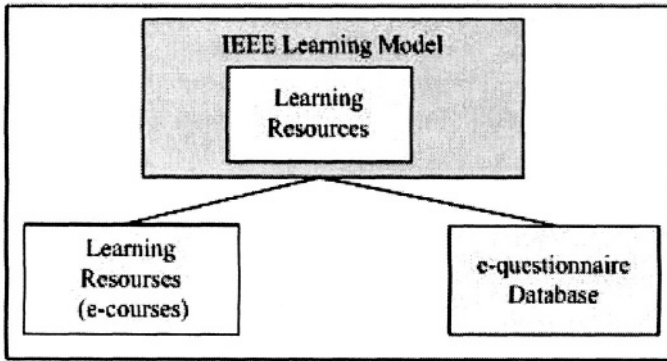

Figure4. Proposed replacement of the learning resources.

For this reason we have enhanced the learning resources component, which stores only representations of knowledge, with the e-questionnaire helping to specific and adapt users' profile within the e-learning system.

In our extension of the LTSA Standard, the learner has been replaced by users like the teacher from a school unit or a group of teachers and the coach has been interchanged with an e-teacher. In order to achieve our scope, we have developed an e-questionnaire through which users' profiles can be extracted, based on users' answers and behaviors. An analytic description of the structure of the e-questionnaire is shown in section 3. This e-questionnaire is stored in an e-questionnaire database which is an extension of the learning resources shown in Figure 4.

The learning resources contain data like e-courses, presentations, multimedia data that a user can access after answering the e-questionnaire. So, when users access the system for the first time, they receive an e-questionnaire via the delivery process which they are asked to answer. Then, their answers are stored as a record in the e-questionnaire users' answers records. These records can be analyzed and statistics be extracted in the form of reports for a variety of topics regarding e-learning and ICT knowledge. These reports refer to the e-surveys which are described in section 4.

Another refinement that we have made to the LTSA Standard is the extension of the evaluation entity to a re-evaluation entity which extracts

users' profiles and conducts surveys (Figure 5). The answers to the questionnaire are used for estimating user's profile (for new users) or adapting existing user profiles. Therefore, users are categorized according to their own profile and own other general profile that the database contains. More information about this procedure is given in section 6.

The behavior system component and the answers to the questionnaire convey the user's component to the evaluation module. It provides "raw" information about users' activities, recorded in real time and used to evaluate the given answers or the performance in courses. User's observable behaviors are inputs to the re-evaluation process. This process produces assessment information (e.g., users' ICT level or grades of users' e-courses) and sends this information to the e-teacher when he asks for it. The re-evaluation process creates performance information that is stored in each user's records. In fact, performance information comes from both the re-evaluation process (e.g, answers to the questionnaire, grades on lessons) and e-teacher (e.g. obtained certifications).

Users' records hold information about the past (e.g., historical learner records), the present (e.g., current assessments for suspending and resuming sessions) and the future (e.g., pedagogy, learner, or employer objectives). The e-teacher could request and receive performance information from the users' records and also store any users' assessment information and certifications.

The proposed system provides information about the user's current state, which is used by the e-teacher to determine optimal learning experiences or to generate statistics. The e-teacher receives the current assessment information from the re-evaluation process and performance information and supports the decision-making process for choosing next learning experiences.

Based on the current assessment information and historical performance information, the e-teacher sends queries to the learning resources so as to search for learning content that is appropriate for the user. The queries specify search criteria based on, in part, learning preferences, assessment information, and performance and preference information.
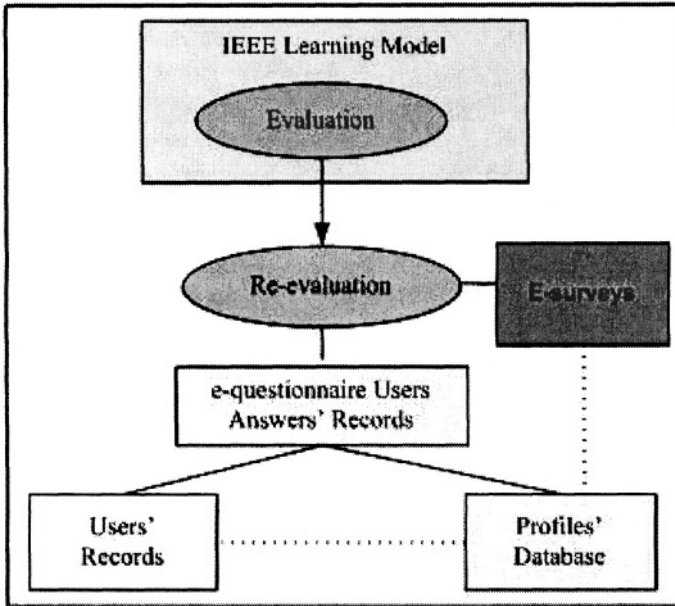
Figure 2. Proposed replacement of the evaluation entity.

The learning resources component stores courses, presentations, tutorials laboratory experiments, and other learning material as resources for learning experiences. The learning resources can be searched by queries. The matched information is returned as catalogue info. The locators are extracted from the catalogue info and can be used by the delivery process to retrieve learning content.

The learning content data flow is a coded representation of material that helps to create the e-teacher as well as to suggest and deliver the learning experience. In fact, the learning content is identified by the locator, retrieved by the learning resources, and transformed by the delivery system into an interactive multimedia learning experience.

The delivery process transforms information obtained via learning content into a presentation, which is transferred to the user. The presentation can be static, interactive, and collaborative or involve experiments and discovery.

The delivery process receives locators from the e-teacher and retrieves learning content from the learning resources. The delivery process transforms the learning content into an e-questionnaire or e-courses for the user. Within an actual system implementation, the delivery process is combined with the re-evaluation process to achieve the tight coupling necessary for responsive, interactive learning experiences.

4. DESIGN AND STRUCTURE OF QUESTIONNAIRES

The proposed questionnaires [5] are developed in the framework of SPERO (Teleinformatics system for continuous collection, processing, diffusion of material for teacher training in special education) [2], a "Leonardo da Vinci" European Programme project.

Firstly, the group of SPERO experts conducted a detailed research in a number of European schools in order to detect a variety of aspects, such as a) the identity and role of teachers in the ICT era; this role is expected to respond to the increasing needs of the current school within the modern social environment, b) the identity of organizations providing teacher training programmes, e.g., universities acting as research and training centers, c) the character of specialized/non specialized training programmes for teachers, d) the attitude of teachers with regard to the use of innovative methods and 'tools', i.e. computers, Internet and software in teaching special education students e) the mechanisms with which European countries train teachers and evaluate training programmes and f) the awareness of teachers with regard to self-evaluation, self-training and life long learning possibilities.

Then, the SPERO users' requirements were analyzed and the educational context was presented to them, especially focusing on Special Education Needs (different levels of education, type of schools, infrastructure of schools, specific national policies) and on the different methods which are used to assess teachers (evaluation procedures). Furthermore, the systematic collection of users' requirements demonstrated the different teacher categories, the educational background of teachers (languages, level of ICT literacy, seminars, training) and the procedures, by which, teachers become qualified in ICT. Following the elaboration of the collective users' requirements, a questionnaire have been designed by the experts. In this questionnaire an explicit segregation of the School and Teacher Profile seem to be essential. So, two separate questionnaires have been generated in order to receive the relevant information. The first group of questionnaires contains questions for school units like the school unit description, students and teachers' population, special educational needs and training programmes for teachers or students from government services, European Union or other organization.

The other group contains questions for teachers like their Information and Computer Technologies (ICT) background. The questions, which are addressed to the teachers, are intended to select information about their professional development, evaluation of educational approach and ICT, their

familiarization with information technologies and the pedagogical utilization of new technologies.

After the illustration of SPERO questionnaires,each expert for each participating European country has translated the questionnaires in his language and these translations have been stored in the e-questionnaires database. This group of questionnaires can be accessed through the web server [5]. This design can be extended in a general framework of e-questionnaires which can vary with the educational needs of the users.

Another approach could lead to a questionnaire design that can cover the needs of a user who wants to search for a particular object in a (multimedia) database.

5.   CONDUCTING E-SURVEYS

The user answers' records constitute the data for which e-survey is conducted [6]. For this scope, the statistic analysts of the group of experts have analyzed the answers to each question. Moreover the statistical analysis for each country has been performed based on user answers' records through the internet.

The questionnaires fulfil certain requirements in order to ensure that meaningful results are achieved. The data analysts have specified these requirements when designing the e-questionnaires. What each questionnaire is intended to measure has been assigned and assured to be unambiguous and appropriate.

There are various types of validation which we have taken under consideration, such as that data should be complete and cover a broad part of the population for which this survey is conducted. Furthermore, the outcome must be able to be predicted from data, thus sample must be sufficient (10 per cent from SEN school and teachers from participating European countries).

After completion of the collection of users' answers, surveys are conducted. The results of these surveys are the proportions of users' answers per question or the proportions of the users' answers per combinations of questions. In addition, we extract results of combinations of questions and users' profiles. These surveys can be accessed via internet in any language of the participating countries [6].

6.   PROFILE EXTRACTION

The personalization module which extracts the users' profiles, keeps a record of their profiles, containing usage history and user preferences [4]. The user profiles that have been defined by the experts are stored in the profile database. Each one of these describes, in addition to the characteristics of the users it describes, their learning needs and preferences. The answers to the questionnaire are used to select the profile of a new user by finding the existing user profile that best matches the current learner's ICT level of knowledge and peculiarities.

Thus, once a user is assigned to a user profile, the e-teacher uses this information in order to locate in the learning resources store the learning materials that best match his/her profile. A new user profile can be created or existing ones can be adapted based on the statistics of the e-questionnaire database. New user profiles or adapted versions of them are then stored in the Profile Database.

Whenever an already registered user accesses the systems, its profile is restored from the Database Profile. Change of the profile of a user is performed based on the progress of its training. New user profiles are created, based on statistics of the e-survey and are stored in the profiles' database. When users access the proposed system automatically their profiles are recalled from the profiles' database. Any users' level modulation is added to the profiles' database.

7.   E-COURSES: MECHANISM FOR THEIR SELECTION

SEN teachers will be able to take e-courses in ICT as soon as they complete the e-questionnaire. The SPERO group of experts do not create e-course for validating the user profile estimation and adaptation based on the questionnaire answers. Instead of this, a list of available e-courses in the SPERO participant countries or elsewhere, are rated according to the required ICT knowledge.

After filling the e-questionnaire, SEN teachers are transferred to the appropriate e-course (if they are willing to attend such a course). The appropriateness of the selected e-courses are estimated by the answers given in the e-questionnaire. A need to rate existing e-courses according to the required level of ICT knowledge is, therefore, necessary. Rating e-courses takes into account the available SPERO user profiles. It is valuable to link several e-courses to each of the SPERO user profiles. Therefore, e-course are rated so as to correspond to an ICT level. Users receive an e-course and their

behavior is observed. In order to estimate whether the suggested e-course was the one that covers the level of ICT knowledge as well as the requirements of the user, a kind of selection's evaluation is required.

For this evaluation of e-course selection, the behavior of the user when attending the course is recorded, framed in the appropriate context and behavior information is extracted and stored in the user's profile.

8.   TEST BED ENVIRONMENT

The SPERO total system is a learning portal. When users visit this site, they are asked to answer the e-questionnaire. Automatically, after completion of the e-questionnaires, the user profile is established and stored. Subsequently, a registration form is appears in order to declare users' login name and password for SPERO site. Next, users can access the learning SPERO portal. The main menu of the SPERO portal contains links to the following sectors:

- Courses Catalogue: It contains one or more courses which users may take, according to their ICT level which is automatically extracted from the answer to the questionnaire.
- Announcement : The Announcement Service provides a board where topics about e-courses is published.
- Search: The Search Service provides users with the environment to retrieve specific information existing in the SPERO site, e.g. members, school units, e-lessons.
- E-mail: Users can send or receive e-mails through the SPERO site.
- Upload file: Users have their own personal space where they store their own material to which other users may have access to.
- Help: Its primary purpose is to accommodate HTML pages describing the usage and the tasks of SPERO menu choices.

In order to improve the ICT level of learners, different e-courses can be delivered to them according to their ICT level. Indicatively, e-courses with increasing difficulty include some of the following topics:
- Level 1 : Introduction to Information's Technologies (definition of data, bit, byte, presentation of hardware components, presentation of type of software)
- Level 2 : Presentation and usage of operating systems as Microsoft Windows
- Level 3 : Usage of Microsoft Office
- Level 4 : Usage of Internet (Browser, Search Machines, E-mail)

9.   CONCLUSION

Among the research community dealing with personalized learning and intelligent learning applications, it becomes clear that the results to be obtained from any kind of electronic questionnaires or surveys will not have the desired effectiveness, unless major focus is given to the individual user profiling based on their history and preferences and the corresponding user behavior.

In this paper we have presented how e-questionnaires, designed for conducting surveys about the ICT level of knowledge of teachers who work in the special education sector, can be used in the framework of a dynamic distance learning scheme in order to achieve user adaptive learning facilities.

10.   ACKNOWLEDGMENT

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MIRTO: A NEW APPROACH FOR CALL SYSTEMS

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Abstract: The MIRTO project aims at designing a pedagogical plateform using Natural Language Processing (NLP) technologies, meant to be used by language teachers. More than an element of quality, the NLP is prerequisite, as our own, for the language learning softwares to be able to teach language as such. MIRTO tries to work out this approach, while offering an NLP based authoring system to create pedagogical objects, such as activities and scenarios.

Key words: E-Learning, Learning Management Systems, NLP for CALL

1.   INTRODUCTION

It is generally reckoned that computer science can be a great help for language learning; the fact is that language didacticians and computer scientists do not admit the same acceptation of the term "language". The first consider it as a system of concepts, the latter as a system of forms. Such a difference can be easily explained by the fact that computer science can only process the forms of a language when didactics consider the form as the

materialisation of the concepts. Such a duality is visible in the great majority of language learning software and explains the numerous imperfections. That is why the first part of this short paper will present the main limits of current CALL (Computer Assisted Language Learning) systems. The second part will consist in evoking what NLP (Natural Language Processing) technologies can bring to CALL systems while introducing the philosophy of the MIRTO project. Then, we will present its general structure and the related concepts. The fourth part will illustrate how NLP tools can improve CALL'S limits through examples from the prototypal modules developed for MIRTO. Such an illustration will finally allow us to present the future developments and the associated perspectives.

2.   THE LIMITS OF CALL SYSTEMS

Since the outset of Computer Assisted Learning in the seventies, specific CALL products have significantly evolved [POT, 2000]. These evolutions are mainly due to the ones in language didactics and in computer science with, for instance, the development of multimedia and networks. However, three recurrent problems are to be noticed [ANT, 2004].

We can first consider the poorness of meaning associated to any linguistic sequence whatever its length, might it be produced by the software and directed to the student or the other way round. At the production as well as the reception of a linguistic sequence, software applications generally consider only a single predetermined aspect of the latter. Effectively, words, syntagms (phrases), sentences and texts are still processed as single character strings since computer science uses numerical form to represent an original form. So, morphosyntactic and semantic language features are not taken into account. This involves an incapacity for these applications to take language specific properties into consideration, which limits the interest, the possibilities and the quality of such tools. That is why, for instance, when a sequence as *Mary is the girl you met last week* is produced to illustrate the omission of a relative in English, the only property of the considered sequence is that precise illustration. The fact that this sequence has several other properties, as the fact that Mary is the subject or that met is the past tense of meet for instance, is not considered in the software and cannot be processed.

The second problem stems from the rigidity of CALL software. It limits the examples to a finite and predetermined set and only allows to use a given text in a given activity and prevents them from being interchangeable. Most of the time, this does not result from a pedagogic choice contrary to

language didactics which can provide open and variable learning contexts as well as adapted exercises for a learner. Computer science would not be able to transform this didactic set of problems in programs without using other kinds of knowledge and competence.

Finally, the third problem concerns the fact that software applications are computer sciences oriented. This orientation forces the language teachers with no or little computing skills to manipulate concepts which do not belong to their set of problems. Thus, instead of expressing pedagogic answers, they are constrained to look for computerized solutions, which connect as much as possible with their own models or pedagogic propositions. Effectively, early CALL systems used to be perfect computerwise but lacked interest on a didactic point of view since it was necessary to have notions in programming in order to design interactive courses.

3. THE MIRTO PROJECT OR THE CALL/NLP COUPLING

In the perspective of covering up these limits, an orientation towards the development of a user-oriented, NLP based, teaching platform appears to be a straightforward answer [ANT, 2002].

Effectively, CALL systems often consider language as given information without being able to take its specific properties into consideration. However, it appears necessary that this material should be processed and then controlled. NLP can bring solutions since its scope of competence stands between linguistics and computer science. It allows to consider the meaning of linguistic form in the way of various applications, but also for language teaching since it offers the possibility of using corpora, detecting and analyzing errors or diversifying learners' pedagogical course.

We lay stress on a real consideration of the different disciplines involved which are as many necessary conditions to overcome the present limits of CALL systems.

3.1 Natural Language Processing

The set of NLP problems can be summarized with two theoretical goals: automatic analysis and automatic generation [BOU, 1998]. Automatic analysis aims at formally representing, by successive parses, the meaning of a written or spoken form. The one of the generation is to automatically produce texts in one particular language or speech with a formal representation of an informative content. In order to reach these goals, parses

are made on four levels which sometimes overlap each other: lexical, morphosyntactic, semantic and pragmatic [FUC, 1993]. The results of each level are obtained by the use of programs. Those programs use methods which exploit forms and associated meaning properties. We can notice that it is not computer science methods which are used but linguistic ones. Even if NLP goals are not reached, some results, as the lexical and morphosyntactic ones, are sufficiently significant and exploitable. Nowadays, each application dealing with human-machine communication is, or will be, concerned with NLP results since every communication has to use language and natural language since it is the most appropriate language for a human. Thus, it appears paradoxical that NLP technologies have been forgotten in most CALL systems, but a few such as ALEXIA [CHA, 2000] or ELEONORE [CHA, 1995], since CALL manipulates language. But as for us, this relative absence is mainly due to a lack of knowledge about NLP for CALL since it can provide a very favourable efficiency-gain-to-additional-cost ratio.

3.2   Use of NLP technologies for CALL systems

The task of NLP is dual: it means an ability to formally determine and represent the informative content (meaning) of whatever language sequence and the possibility to convert at least one sequence from informative content to the formal representation. Those two processes suppose an ability to handle and exploit four kinds of data without associated knowledge: series of characters (morphemes) and their linguistic properties. As we have already noticed, NLP technologies offer satisfying results on characters and words parsing, and great progress concerning sentences.

Hence, concerning the advantages of NLP technologies to cover up the limits of CALL systems [SEG, 2002], several aspects of such a pairing seem conceivable. We can notice that the detection and extraction of words of a text with morphosyntactical criteria may lead to automatic generation of gap-filling exercises. The latter may use the error detection and analysis with "intelligent" feedback. Such an analysis can bring a qualitative exploitation of the learner's course, thus more adaptation and diversification.

The MIRTO project aims at designing a platform for teaching languages and subjects using linguistic material in order to solve some limits of CALL software. It puts its approach into practise while developing a user-oriented NLP based teaching platform and offering new perspectives for CALL systems.

Language teachers are allowed to query for texts or parts of texts according to pedagogical criteria. According to this hypothesis, those texts are to be the basis of their activities or scenarios.

The MIRTO project is determinedly pluridisciplinary, and aims at giving an NLP toolbox to language teachers in order to design scenarios in their own pedagogical set of problems.

4. GENERAL STRUCTURE OF MIRTO

The main goal of MIRTO is to propose to the language teacher the possibility of designing pedagogical scenarios while fully taking advantage of NLP technologies in a user-friendly manner. Thus, those scenarios will be open (dynamical text database), will allow an individualized adaptation according to the learner (automated generation of exercises, qualitative evaluation of the answers...) and should allow new po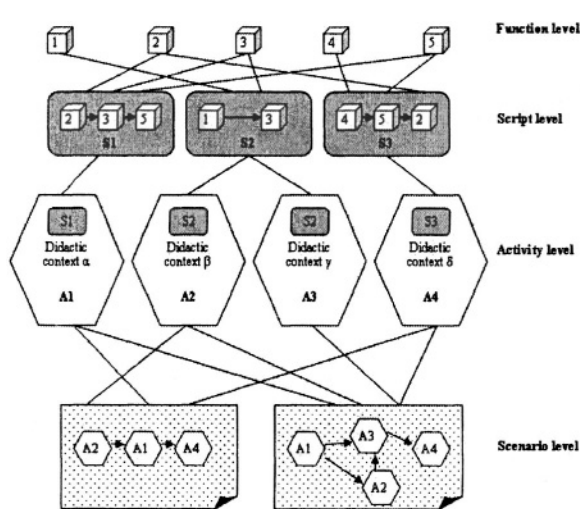ssibilities (work on long texts, automated production of aids or exercises, design of non-linear scenario ...). The approach of MIRTO is determinedly user-oriented since it is meant for language teachers who, a priori have little or no skill in NLP nor in computing. The technical nature of NLP has to be transparent to the language teacher and only the didactic aspects are to be visible and available to him.

Figure 1 - MIRTO Levels

In that way, four hierarchical levels (function, script, activity and scenario), associated with the text database, structure MIRTO as it is illustrated on figure 1.

4.1 Function level

The functions represent the lower level MIRTO objects. They correspond to a basic NLP process such as tokenization (text splitting in forms) or language identification. Considering its technical nature and its

independence from a didactic application, this level is not visible for the users.

4.2   Script level

This level corresponds to the application of NLP functions to language didactics. A script is a series of functions with a didactic objective.

For instance, the automated design of a gap-filling exercise is considered as a script because it connects the functions of language identification, tokenization, morphological analysis and gap creation depending on parameters chosen by the user.

The working of a script is hidden to the teacher-designer of scenarios since it is presented as a toolbox.

4.3   Activity level

This level with the next one (scenario level) is the didactic core of MIRTO. An activity corresponds to the didactic contextualization of a script (previous level). Its goal (figure 2) is to associate a script with a text from the corpus database, an instruction, possible aids and a facultative evaluation system.

In order to create a gap-filling exercise, one only has to choose to apply the script of the previous example to a text while specifying the gaps criteria (for instance, hiding the preterit verbs and replacing them by their infinitive form), associating an instruction as "Fill in the blank with the preterit form" and specifying the evaluation form of the activity.

The activities definition is realized by the teacher through an adapted authoring system.

4.4   Scenario level

This level allows the teachers to define the sequence of activities in order to answer to their pedagogical objectives throughout the learner progression. This expected progression is not the same for each learner. Effectively, each of them will have a personal learning process linked to different factors. MIRTO is dealing with that reality while proposing non-linear scenario creation. The path through the scenario depends on the individual process of each learner (learning course, evaluation...). That course is stored in a learners' tracing database. For instance, according to his progress in a given scenario, a learner can be redirected to remediation activities, or retry an activity on another text or simply advance in the scenario.

A MIRTO first prototype is being developed right now. The first two levels (function and script) are achieved and the two others are the goal of a current work. The next part presents this realization through examples of activities and scenarios already developed.

5. THE MIRTO PROTOTYPE

The MIRTO prototype may be described as two main modules: the NLP module and the didactic module. The first module allows an NLP specialist to create scripts. By using these scripts, the didactic module offers to language teachers an authoring system in order to create both activities and scenarios.

5.1 The NLP module

In order to design this module, we needed a system that would both be able to integrate NLP tools and to associate them. We are providing a graphical environment in order to create scripts. This interface allows to consult all available functions within the platform. The aggregation of those different functions will constitute the script. The chaining of scripts is weakly constrained. Once validated, the script is stored in a database, so that it can be reused.

Our interface allows us to easily integrate NLP tools, to test them, to connect them (when their outputs are compatible) and then to elaborate MIRTO scripts. However, these script creations must be the result of a close collaboration between a didactic expert and an NLP specialist. Effectively, a script expresses a didactic goal (cf. §4.2).
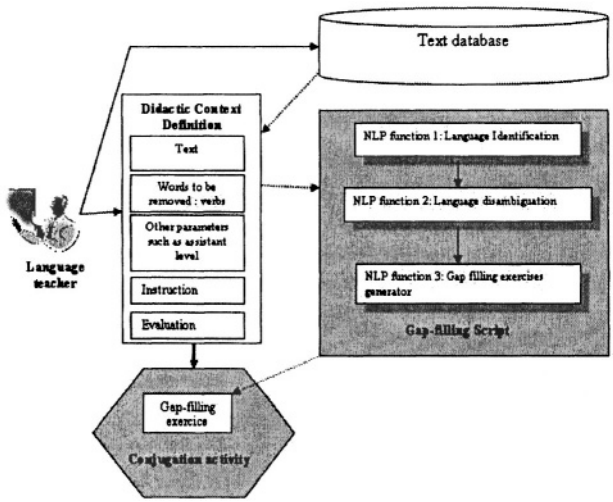
5.2 The didactic module

For our first prototype, we have chosen to develop mainly a module allowing to show the NLP potential for CALL. This module deals with the two main didactic MIRTO levels: activity and scenario.

5.2.1 The activity design module

This module can be represented as an authoring system with a script toolbox where one can create activities as gap-filling exercises for instance (cf. figure 2), but where the result is managed through a MIRTO script and where each word is associated with linguistic features.

We are able to generate activities using NLP based tools so as to give a meaning to a sequence, without requiring the designer to be a computer scientist. Effectively, simple NLP applications can add a lot of functions to the activities. A set of generation rules, that is to say the script, allows to determine the form and the grammatical features of the words that are to be removed, and the information that are to be shown in the gaps. These kinds of activities allow the learner to have access to additional information such as a comprehension assistant: grammatical information or links to external resources (hypertextual links) which are automatically added. Moreover, these activities can offer a lot of advantages on evaluation, which gives the possibility of creating non-linear scenarios or advanced feedbacks.

Activities and their linguistic features are stored in a database. Thus, they can be easily modified or shared. Those NLP based activities allow to suggest potential answers to the language teacher. However, in case of ambiguities, the activity designer may be able to modify the "system answers". He will have access to both answer handling and test modes, and will be able to modify activities by removing a "gap" for instance.

So, he can adapt and diversify his activities, which can be also possible through an existing scenario.

Figure 2 - Use of MIRTO scripts to design a didactic activity

5.2.2   The scenario design module

Another aspect of the didactic module is the creation of pedagogical scenarios. We have chosen, similarly to activities, to conceive a user-oriented scenario design interface. We have then developed a user-oriented Java prototypal applet in order to design tree structured scenarios. The pedagogical designer will choose activities objects and will join them with a simple arrow. He will be able to devise the pedagogical course process of the

activities. The configuration of transition from an activity to another is being developed as well as a "tracing" module, but they will depend on NLP error analysis possibilities and on the kind of activities. As for the activities, scenarios involve much flexibility and the language teacher could imagine and design scenarios which will be easily adaptable and variable.

6.   PERSPECTIVES

After presenting what is already developed, it is necessary to stress on perspectives and future developments. The first one is the integration of an answer analysis module. We are working on a learner corpora analysis in order to define a reliable error analyzer involving advanced evaluation. It will allow to improve the non-linear scenario design and will give the possibility to individualize further learner courses, thus providing a great improvement for the learner's production. Effectively, such an answer analyzer must be able to locate orthographical errors as well as the non-acquisition of a grammatical notion.

We are now developing the "tracing module" in order to manage with non-linear scenarios and the visualization of the learners'course : the effective work, the collection of errors, their analysis, the aids used or the duration. The tracing will allow the teacher to access to what is acquired or not. He will be able to adapt his lessons in presential classes or by the help of others MIRTO scenarios depending on the entire group results.

Furthermore, we are concurrently working on the design of a "pedagogically indexed text-database" [LOI, 2003]. This database should allow teachers to find texts according to pedagogical criteria such as what activities to perform with the text. Once available, it should be integrated within the MIRTO platform, thus broadening the perspectives in terms of activity authoring. Such a database should allow them to query for texts or parts of texts according to pedagogical criteria. For instance, an English teacher should ideally be able to query for a text to introduce the present simple in contrast with the present continuous to a class of French beginners. The teachers should be able to add their own texts to the database in order to share them with peers and benefit from each other's experience.

In the long run, we consider to integrate MIRTO in a pedagogical platform which would allow to manage with pedagogical resources organization, the users and collaboration tools and to propose the possibility of designing non-NLP based activities. We go towards a pedagogical authoring system based on the NLP possibilities and on the didactic set of problems of language learner.

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USING LEARNING THEORIES FOR EDUCATION ON THE WEB

A Web Application for Teaching and Learning Computer Networks

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Abstract   The objective of this paper is to present a Web application, constructed in order to help and guide teachers and learners of computer networks. This application defines a context for teaching and learning which is based on a methodological approach stemmed from some modern educational theories. Concept maps, a graphical representation of the relationships among concepts, are used to model and organize the knowledge of the application domain, in our case, computer networks. This application offers a very concise form to present the concepts and principles to be taught or learned and consequently to organize the educational process. Guidelines for using this application and its associated environment are also presented.

Introduction

One of the most important skills required by the new engineering profile is the capability to acquire knowledge in a continuous and incremental way. In particular, the fast technological changes require a constant improvement in technological education.

In this paper, we choose computer networks as a good example of a domain with a continuous change of the technological contents. Furthermore, the high complexity and the great diversity of the contents related to computer networks is another question to be solved for the development of learning.

To better develop this kind of courses, alternative methodologies must be considered in the curriculum organization and implementation. These methodologies need to deal with the learning of the underlying concepts of the domain and, at the same time, the preparation of the students for their professional life, in a world with a continuous process of technological changes.

In this context, we present some methodological guidelines and a Web application to improve the teaching and learning of technological courses. Our methodological approach combines the *generative themes,* proposed by the Brazilian educator Freire, 1981, and the *assimilation theory* and *concept maps,* proposed by Ausubel et al., 1980.

In the next sections we present the principal contributions of educational researches used in this work and the *concept maps.* After that, we discuss the *knowledge representation* applied to computer networks domain. Finally, we present the structure of the *Web application* proposed in this work, showing how teachers and learners of computer networks course can use this application.

1.   Methodological Considerations

The Brazilian educator Freire, 1981, brought some important contributions for the educational process. His ideas have been applied in general education, including also science and physics education (Delizoicov et al., 2003). According to Freire, 1981, the learning activities must be developed around *generative themes* that are part of the students cultural environment. The *generative themes* increase the motivation of students and allow them to extend their knowledge about the subject, including social and political factors that can contribute to form complete citizens with critical minds.

If we take our domain of interest, the computer networks, we can see that the Internet and its applications got into the homes and businesses of millions of people worldwide, changing the peoples way of life. So, the

Internet can be used as a key *generative theme* to anchor the educational process.

The *generative themes* present a *rupture* in the way of curricula have been elaborated, which are, normally, strongly based on contents, organized in a rigid and systematic manner. In a dynamic domain, with a lot contents, like computer networks, the use of *generative themes* is a good criteria for helping in the selection of contents.

To use these ideas is important to relate the *generative themes* with the *fundamental concepts* that allow giving a global vision of the theme.

The *assimilation theory,* presented by Ausubel et al., 1980, can help in the this process. This educational theory describes how the students acquire concepts and how these concepts are organized in their minds. For the *assimilation theory,* the learning occurs when a new information is obtained from a planned effort by the learner to link this information with some relevant concepts already existing in his/her *cognitive structure.* To accomplish this task, the suggestion is to start the learning from more general and comprehensive concepts and then, to go towards more specific ones.

To use the *assimilation theory,* one important task is to determine the *conceptual structure* of the domain to be taught. In other words, we have to identify the underlying concepts and principles of the domain and hierarchically organize them, from the more general and inclusive concepts towards the more specific ones. Afterwards, this *conceptual structure* can be used to put the learning in sequence.

The *concept maps,* developed by Novak, 2003, in the sequence of researches about the *assimilation theory,* can help in this task.

The *concept maps* are a kind of graph used to represent the relationships among a group of concepts. To each node of the graph a concept can be associated. The labelled links between nodes show the relationships among concepts. The figure 1 and 2 are examples of *concept maps,* the first shows a brief picture of the computer networks evolution, and the second shows a global vision of the Internet and its principal services.

In the *concept map* representation, concepts are represented in a hierarchical way with the most general and inclusive concepts at the top and the more specific ones organized hierarchically below. For a concept corresponding to a node, it is also possible to build another *concept map* with the objective of refining it.

Concept maps have already been used for a variety of educational purposes (Novak, 2003; Cañas et al., 2003). The *concept maps* can be helpful to clearly present the material to be learned, identifying the large general concepts prior to instruction and assisting in the sequencing of learning through progressive and more specific and explicit knowledge.

Based on these educational contributions, we intent to use *generative themes,* to anchor the curriculum, and to model the knowledge of the domain to be taught or learnt using *concept maps.*

In the next section we discuss the *knowledge representation* of computer networks domain and the use of *concept maps.*

2.   Knowledge Representation In Computer Networks Domain

In a traditional teaching approach, the curriculum is organized by following the classical structure of the programmatic contents of a course in a rigorous way. The contents are previously divided into topics and presented sequentially and in depth to the students. Normally, the teaching is based on textbooks, which are used by teachers as the principal didactic material.

In a domain with a continuous change of the technological contents, as are the computer networks domain, this approach has some limitations. The great question is how to select and organize the contents to be taught.

To organize the contents, many computer networks textbooks divide the chapters based on the *layers* of network architecture, like in Tanenbaum, 2003. This way of organization largely influenced the teachers of computer networks during the last years. Normally, the courses were strongly based on the contents, with each topic or protocol being studied in depth as an individual component. A common approach for explore the contents was cover the layers in a bottom-up manner, following the book organization, starting from the physical medias and finishing with the network applications. Frequently, the network applications were not discussed due to the lack of time and also because they were considered less important in the point of view of the network developers.

The rigid pedagogical material of textbooks, associated with the high complexity and the great diversity of the contents, do not motivated the students, imposing great difficulties for they understand concepts and relate the topics under study with real applications.

Kurose and Ross, 2000, innovated with "a *top-down approach* featuring the Internet", which begins at the application layer and works its way down the layers. According to the authors, the *top-down approach* has several important benefits. It places emphasis on the application layer, which is the high growth area of computer networks. It is a powerful approach to motivate students. It enables instructors to introduce network applications development at an early stage.

Starting with the use of networks and global behavior we can affirm that we are closer to the ideas of *generative themes* of Freire, 1981, which increase motivation and give an explicit meaning to the knowledge taught.

However, inverting only the way of exploring the layers is not sufficient. It is also interesting to explore the concepts and technologies in a *general-to-specific* manner, in order to facilitate acquisition of *fundamental concepts* by the learners.

The importance of the *fundamental concepts* is also emphasized by Peterson and Davie, 2000, which is loosely organized their textbook around the *traditional network layers.* The authors propose to "start with the *first principles* and walks through the thought process that led to today's networks". They say that in a dynamic and changing domain as computer networks, "the most important thing a textbook can offer is perspective to distinguish what's important and what's not, between what's lasting and what's superficial".

However, this approach can also be enriched organizing the concepts in a hierarchical manner, from the *general-to-specific* concepts, placing each one in the global view of networks.

Despite the development of computer networks, when we analyze its historical evolution, we can see that many *fundamental concepts* remain unchanged. The *concept map* of figure 1 shows some *fundamental concepts* of computer networks throughout time. Once you understand these concepts, any new problem or technology will be relatively easy to appreciate. So, a reasonable approach for a computer networks course should focus on the *current networks technologies* and search for the *fundamental concepts* which allow the understanding of these technologies.

Different from classical computer networks textbooks, our approach try to start the study with current network applications and technologies, like the Internet and *Local Area Networks,* selecting its *underlying principles,* and exploring its in a *general-to-specific* manner.

Based on a *concept map* representation, the idea is to start from a wide vision of a problem or a theme, looking firstly to its *big picture,* its major parts and the relationship among those parts. After, a part (or a detail) can be examined, without losing the global view. Then, in any time, one can go back to the wide vision to review other parts of the whole problem or topic and to examine the context of certain parts within the whole. Chou, 1999 neatly compare this approach with a photograph using a *zoom lens.*

For example, suppose that someone wants to teach the topic *reliable data transfer,* offered by the *connection oriented service* of the Internet protocol *TCP.* The first thing to do is to place the topic in hand into
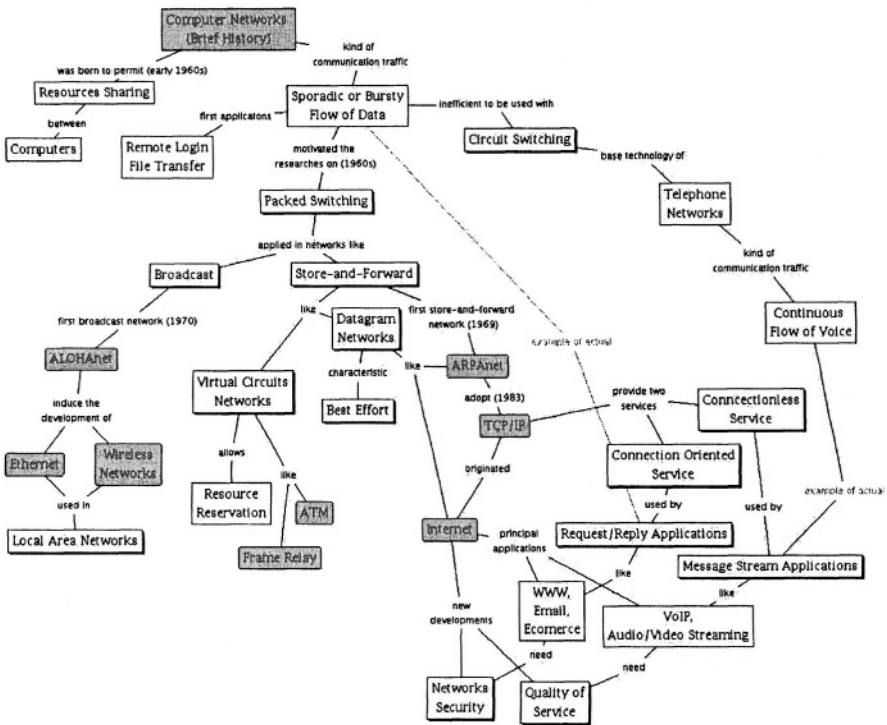
Figure 1.   A brief picture of computer networks evolution

the global view of the Internet technology. The *concept map* of figure 2 shows a manner of doing it, showing how each concept are related with each other and its role in the global behavior of the Internet.

After that, the *connection oriented service* of *TCP* protocol can be detailed, as show the figure 3, where the main concepts related to a *reliable data transfer* are taken into account.

These *concept maps* (figure 2 and 3) can be used to structure the learning process. They are examples of how *concept maps* are incorporated in a *Web application* presented in the following.

3.   Educational Framework For Teaching And Learning On The Web

In this section we present a *Web application,* constructed in order to help and guide teachers and students to organize and improve their activities.
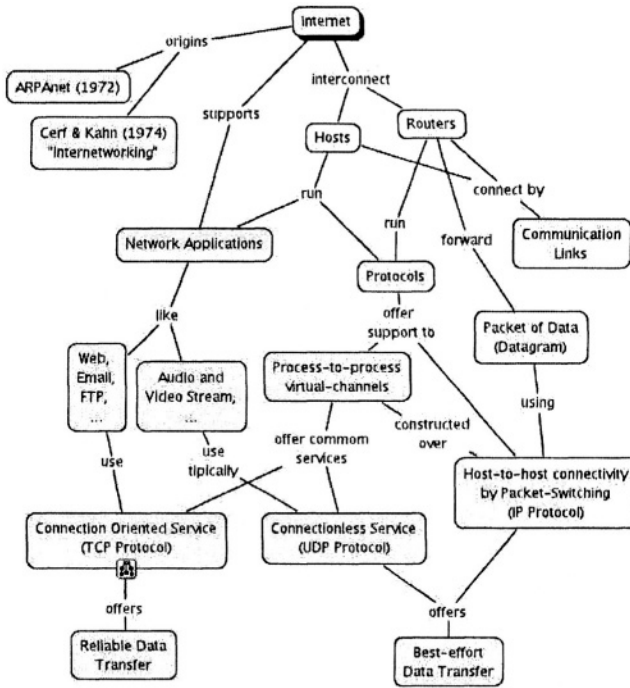
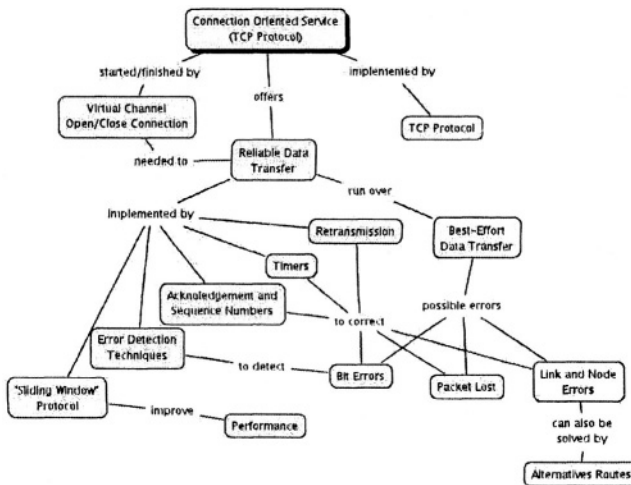*Figure 2.* Vision of principal Internet services

Figure 3. The problem of reliable transmission

The *concept map* in figure 4 represents the roles and the composition of each part of this application.
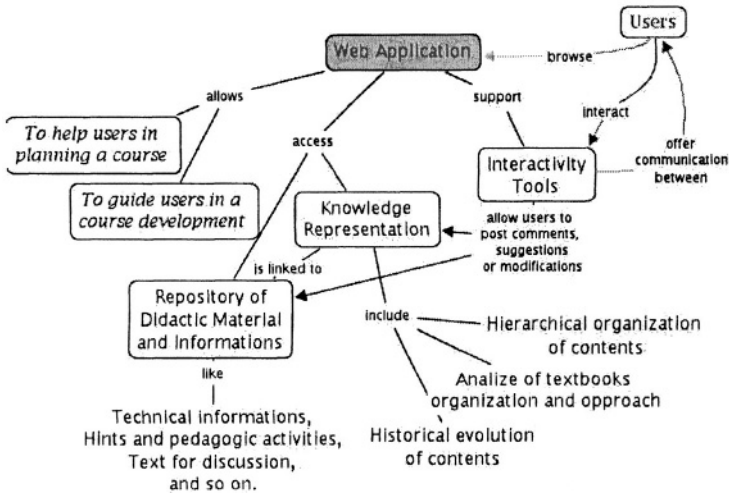

Figure   4.   Roles and composition of the educational framework

The users can browse on the *Web environment,* searching for information, getting help in planning a specific course in computer networks domain or to be guided during the development of a course.

The environment can provide access to a *knowledge representation* of the technological domain, constructed by *concept maps,* associated with *didactic materials* and other storage information. Special *links* can be assigned to each concept in a *concept map* to highlight other elements of the concept, including texts, pictures, technical references, access to other related Web sites and so on.

Users can also interact with the application by means of tools that allow interactivity with the system and also with others users. It's possible for users to post suggestions or comments about the information on the Web, to access *frequent asked questions,* and to discuss with other users about specific themes.

The *Web environment* is being constructed using *educational tools.* The **IHMC Cmap Tool**[1] is being used to build the *concept maps.* The tool also permits us to export the *concept maps* to HTML format to be accessed in a Web environment.

By using the environment, the application can help educators in planning a course offering general options of *concept maps,* where topics, concepts and technologies are hierarchically organized.

To enrich the educational process, to each main concept is associated some *didactic material,* making a scenario to guide the teacher in the development of learning.

Learners can also use the application to browse and search for information. The graphical and hierarchical nature of *concept maps* helps them to keep any concept well placed in the hierarchical structure, without losing the global view. From a concept, students can access documents, videos, simulation *applet* or other information related to this topic.

At the moment the development of the *Web environment* has arrived at a preliminary phase, where we are linking the knowledge structures constructed by *concept maps* to related information. We are also elaborating and systematizing *didactic materials* to be added into the application.

Conclusion

In this paper we presented some methodological guidelines to be applied in computer networks teaching and learning, stemming from some modern learning theories. An *educational application,* constructed on the Web, synthesizes our approach. Teachers and learners of computer networks can use this application in order to help and guide their work. The application is based on *concept maps,* a graphical representation of the relationships among concepts, used to model and organize the knowledge of the application domain. With the *concept maps,* the knowledge is organized in a hierarchical way, with the most general and comprehensive concepts on the top and the more specific ones, arranged bellow the map. This organization facilitates the developing of learning following a *general-to-specific* approach of concepts. *Didactic materials* are also part of the *Web application* and can be used by teachers in their activities.

Notes

1. **IHMC Cmap Tool** is a tool for construct *concept maps* of The Institute for Human and Machine Cognition (University of West Florida, USA). http://cmap.coginst.uwf.edu

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A LOOK AT THE LEARNING PROCESS IN REMOTE LABORATORY
Tele-experimentation situations at ICAM

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Abstract: The aim of this paper is to present several steps of the methodology that have been defined to analyse a learning situation of tele-experimentation at ICAM (High School of Mechanical Engineering). According to the pre-defined objectives, we establish a framework based upon Activity Theory that will lead us to the definition of indicators i.e. granular key-elements and thus to the effective elaboration of questionnaires and observation grids.

Key words: Remote laboratory; Tele-experimentation; Activity Theory; Learning process.

1.   INTRODUCTION

In this paper, we present a pedagogical analysis of the learning process of students, using an experimentation platform of a remote laboratory carried out at ICAM[1] Institute in Lille. The experimentation platform is the main contribution of ICAM in the European Project of Divilab (DIstributed VIrtual LABoratory)[2].

The Divilab project aims at proposing a generic concept of remote laboratory allowing learners to realise their practical work (in Experimental Sciences) at distance by means of multimedia tools and accessible via Internet or intranet. Thus, the Divilab environment is concerned with virtual laboratory works e.g. interactive manipulation of virtual objects with a 3D interface as well as a distance real time laboratory.

At ICAM, the remote experimentation is applied to the domain of Automatic control dedicated to postgraduate students i.e. engineers in initial formation whereby hundred of them are involved.

The main objectives aimed by the Institute are:

- to offer an experimental and distributed environment which is flexible and freely accessible by learners i.e. without time and space constraints. Indeed, the main objective is to offer self-training to students in such a way that they can consider different points of views about their experiment, and getting involved in reflective activities through inductive approach to learning.
- to enable the learner to develop scientific knowledge and know-how in the domain of the automatic control called "digital control of continuous dynamic system", and to enforce cognitive appropriation. The purpose is mainly to develop the learner's autonomy, to motivate him to become more active in his learning process and to encourage the collective work (richer exchanges) within the experimental activities.
- to initiate innovative educational approaches based on the use of technologies so as to enhance the quality of scientific teaching without raising costs .
- to encourage the mutualisation and the sharing of experimental equipment, often very expensive, between partner establishments.

This paper has been co-authored by the two following authors, Patricia CAPPELAERE as PhD student in Educational Sciences whose role consists in setting up the pedagogical analysis of the environment as part of Divilab with Dr Allal SAADANE, from ICAM, as responsible for the research

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[2] EC. Contract IST 1999-12017

program of the tele-experimentation platform and for the global evaluation of the whole system.

The paper is composed of four parts. The first part gives us a general view of the ICAM tele-experimentation platform and of the learning activities within the remote laboratory. The second one presents a basic analysis of the mediated environment which allows us to apprehend the way it is articulated. The third one proposes the Activity Theory as an analysis instrument with which some triads would be defined. Finally, the last one presents the core of our analysis studying the triads related to the learning context with the intention to elaborate questionnaires and observation grids.

2. DESCRIPTION OF THE ICAM TELE-EXPERIMENTATION PLATFORM

The aim of the ICAM tele-experimentation platform is to develop learning activities through the implementation of computers in the experimentations.

2.1 General presentation of the technological device

The conception of the platform gives the learner the possibility to realise experimentations at a distance and on a real device, apparatus situated in the Institute laboratory controlled from a graphic interface on the learner's computer via Internet. This one is linked with an internal computer having appropriate software and hardware at its disposal and keeping the control functionalities. The computer controlling the real apparatus e.g. the experimental benches is distinct from the one which lodges the server. In other words, this remote laboratory offers remote access to real laboratory equipment and instruments.

2.2 General presentation of the learning activities

The platform offers three tele-experimentation activities whose topics are: Initiation to the identification methods of linear systems, Polynomial control of linear system and Control of the MIMO systems i.e. multiple inputs/multiple outputs systems.

Five lab sessions (each one for a duration of four hours) cover the whole three tele-experimentation activities with the participation of twelve to fourteen students. These ones are invited to work in small groups of two or eventually three people if need be (binomial or trinomial groups). Every lab

session is composed of six groups of two or three students. The entire class is shared into two groups having freely register for remote or local lab sessions from the beginning to the end of the teaching.

Computer application as online simulation for each activity is proposed to the learner so as to test and adjust the control parameters of the studied process before starting the experimentation on the real and remote system. The online simulation, used as part of design methodology, also helps the learner to predict the behaviour of the process and its limits.

The assessment of the practical works by every group of students relies on returned intermediate reports made online recapitulating the theoretical parts, the experimental protocol justified, and presenting the discussed results and argumentative conclusions. The report must also specify the gap or the differences between the obtained results with simulation software, and those obtained through the physical system. A lab session exam is organised by the tutor in the local laboratory to give final assessment.

In its actual version, the communication tools between the learning community for the tele-experimentation are not integrated into the platform. Indeed, the eventual interactions between learners and the tutor online basically rely on the electronic mail (asynchronous mode) and on the telephone (synchronous mode).

For each activity, learners have at their disposal online:
- the description of the experimental process
- the description of the objectives to achieve for the practical work
- a presentation of the structure and the objectives of the control system that they wish to put into work
- an online course support
- an interface allowing to achieve by choice, either an online simulation, or an experiment on the distant experimental process.

The remote environment is the translation of in-situ laboratory experiments to distance learning[1]. Some publications about the architecture of ICAM platform and more details about ongoing works and other aspects of this kind of distributed environment will be done later on.

3.   BASIC ANALYSIS OF THE ENVIRONMENT FOR IDENTIFICATION

First of all, we have based our analysis on the nature and the type of e-learning education for which the laboratory focuses on. We have thus selected three characteristics which identify the tele-experimentation platform and its own context. We think that these ones play an important

role in behavioural aspects of learners as well as in the pedagogical position of the tutor with regard to the learning activities.

The first characteristic leads us to distinguish two types of remote command and control which mainly determine a tele-experimentation situation : the tele-operation and the tele-piloting[2]. Tele-piloting consists in driving, directing a remote system e.g. a car or a robot. More generally, tele-operation consists in making the remote system functioning. The tele-experimentation in the ICAM environment is related to the principles of tele-operation since it includes an internal computer connected to the physical system and operating a remote command without the move of this one.

The mediation i.e. the way the platform is mediated states an horizontal type of mediation. Indeed, the learner's computer is located on the same level as knowledge that is to be acquired. The computer typically plays the role of a tutor or a companion, helping the learner to attain focused objectives. The computer which is the main artefact in this environment intervenes all along the learning process and is entirely integrated into the core of the environment.

The third characteristic takes into account the place where the experimental activities are realised. For all students concerned, the tele-experimentation is divided into two levels: local training courses in the Institute (with the presence of the tutor) and remote training courses (with a tutor online in the respect of the pre-defined hours of the lab sessions). The appropriation of knowledge is shared with home (remote lab sessions) and the Institute (local lab sessions). The online environment is then usable in both local and remote mode where the learner can choose his best moment to work.

4. THEORETICAL FRAMEWORK AND ANALYSIS STRATEGY

In our analysis, we emphasize on the learning process, especially the interaction between learners and the mediated environment. Our analysis object is to define how the learner realises his activities within the mediated environment, and to determine the whole processes and the learning strategies deployed to learn and to reach goals. Thus, our study aims at passing judgement on the act of learning, the process, and not on the result of this act, the product.

Activity Theory constitutes the theoretical framework of our analysis since it helps us to understand the learner's actions, mainly his purposes, the aim he deploys in exploring, for example, an hypertext or an hypermedia. Activity Theory takes into account the context in the understanding of an

activity. Engeström[3] (1987) proposes us the expanded model of an activity involving a set of nodes open to interact between them (see the figure bellow). This model not only considers the action mediated by artefacts (tools) but also a community context with the addition of rules and divisions of labour. For our part, it gives us the possibility to make correspondences between our specific triads and the real activities of the learner.
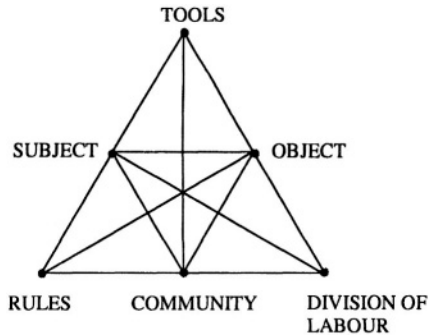

Figure 1. Expanded model of Activity

This model can be summarised as describing human activity as an object transformation process including :

- A *subject :* every human beings involved in the activity
- An *object :* the objectives that motivate the activity
- *Tools* : the mediated environment, material and human resources
- *Rules* which express implicit or explicit norms, habits, etc
- *A Community* : the environment in which the activity takes place
- A *division of labour* : the assigned roles as well as the schedule

According to this theoretical framework, we can define the nodes in relation with the tele-experimentation. The nodes and their characteristics are based on the learning scenario and on the orientation that we wish to lead for our analysis. Thus, the subject is the learner, since our look is centred on the learning process. The object is regarded according to each lab sessions for each has different objectives for the realisation of the activities. The tools concerned are the material and symbolic ones : Internet, simulation software, online contextual documentation according to steps in the scenario, communication tools like electronic mail and telephone. For its part, the community refers to all the learners sharing the same object, i.e. the group of two or three students according to the experimental context, and the tutor online. The division of labour, in our analysis, implies the horizontal repartition of actions within the group and between different groups. Finally, the rules concern the norms and the implicit and explicit practices which

support and regularize the actions and the interactions within the system. This pole is separately analysed as a pole intervening, in some ways, in each triads that we have defined.

5. ANALYSIS METHODOLOGY

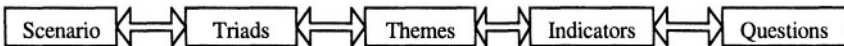Our analysis methodology is articulated around the following structure of work:

Figure 2. Structure of work

Regarding the pre-defined scenario, we have considered the most representative triads of the learning situation in order to study different approaches of our analysis. Each triad is related to a theme so as to characterize the choice and the nature of our indicators, key elements orienting and conceptualising our questions and our interrogations. The final structure of this work results in the elaboration of questionnaires submitted to the students and our observation grids.

5.1 Our selected triads

Each triad concerns three particular nodes, but is kept implicitly linked to the whole other nodes of the activity.

5.1.1 Triad tools/subject/object

This triad is translated by the following question: how does the learner use the tools to realise his object? The relation between the three nodes is referred to the theme as follows: the learner's adaptation to his environment.

The concept of adaptation gets us to analyse the conditions of the realisation of the learner's activity within the environment and to analyse the visible learner's behaviour.

We determine three indicators:
- the obstacles and the facilities of tools use : this indicator allows us to know whether the tools facilitate or constrain the learner to realise his activity, and to precisely define the degree of learner's mastering concerning the use of tools during his learning process. Is there familiarity or dismissal?

- the relevance of tools use : this indicator is analysed according to the relation between the expected uses and the real ones so as to define the tools' appropriateness with the pedagogical objectives.
- the realisation of tasks : this indicator induces us to know whether the learner realises the different tasks of the experimental activity by following the expected directives and protocol.

5.1.2   Triad subject/tools/community

The study of the triad brings us to the question: how does the learner move closer to the community and which tools does he use for that? The theme is based on the individual and interpersonal interactions between the learners.

We retain as indicators the analysis of the interactions between:
- subject/subject "in" : interactions between the subjects belonging to the same binomial group.
- subject/subject "out" : interactions between subjects belonging to different binomial groups.

These indicators rely on a quantitative approach regarding the subject's exchanges with the tools used.

5.1.3   Triad subject/community/object

The question is to know : how does the subject use the community to realise his object ? We have retained the notion of interdependence between the subject and the learning community as theme.

Corresponding to this, the indicators are:
- the learner's integration into the community.
- every kind of help and remediation processes when realising the experimental activity.
- the realisation of the tasks, more precisely the way the subject follows his activity through, within the community.

Theses indicators allow us to analyse the learner's behaviour and aptitudes for decision making, for auto-evaluation and for hetero-evaluation processes. In other words, we wish to know his personal and social implication in the environment with the view to determine his position (active or passive) in the realisation of the activity.

5.1.4 Triad community/tools/object

This triad is related to the following question: how does the learning community use the tools to reach the object? Here, the theme is defined as : the analysis of the interactions between the agents, i.e. learners and tutor[4].

Different types of interactions within the community can be interpreted according to the use of tools, to the related objectives, and to the implication of the agents.

Our indicator considers the relations between the number of people involved in the activity: the role of these people, tools and objectives. We thus focus on the following interactions:

- Binomial group/binomial group : interactions between binomial groups of students.
- Tutor/ binomial group : interactions between the tutor and a particular binomial group of students.
- Tutor/binomial group/binomial group : interactions between the tutor and several binomial groups of students, for example.

This indicator takes into account the frequency and the quality of the types of interactions, in order to know whether the interactions express an information or help request, a proposition in or out of the context of the learning process according to the use of tools, and in the synchronous or asynchronous communication mode.

This indicator handles a quantitative and qualitative approach of the interactions.

5.1.5 Triad community/subject/division of labour

Here, we ask the following question : how does the learner manage his activity with the community and how is the division of labour established? The theme retains the key concepts of collaboration and cooperation[5].

We put our attention on the learner's position and strategies about the management of his work taking the group structure into account. This analysis allows us to distinguish cooperative and collaborative approaches in the learning process[6], i.e. the learner's specific role and actions in the community[7].

The corresponding indicators are:

- the confrontation/juxtaposition of points of view : cognitive and socio-cognitive conflicts
- the management of the activity of every member of the community : the establishment of motives and the distribution of these ones.
- the transformation of representations or points of view .

6.   CONCLUSION

We have opted for a mixed analysis methodology so as to turn the collection of quantitative and qualitative results to good account. The instruments for questioning rely on a survey with questionnaires and observations.

The observations in-situ of the lab sessions enable us to comprehend the way the learners behave in mediated environment and to appreciate their behaviours. The indicators corresponding to our selected triads of the learning situation will support the questionnaires and our observation grids for which related items are defined.

Three questionnaires (with the collaboration of ICAM) will be submitted to students covering the three general steps of the teaching that is to say before, during and after the lab sessions, with the view to appreciate the evolution of learners' considerations about the e-learning situations that the Institute proposes.

At the present time and since the lab sessions are going to start soon, we have submitted a pre-questionnaire to the students, which states three important points. First, their expectations and their commitment in the experimentation platform, for instance their consideration about e-learning situations carried out in a remote or local mode, the resources they feel necessary to realise their experiment in good conditions. Secondly, their experience in e-learning situations. Finally, their experience and knowledge about the use of computer sciences such as Internet, electronic mail, web surfing, forum, etc.

The collect of the pre-questionnaire will be done later on.

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Session 5

Fast Abstracts

AMBIENT LEARNING
The experience of ambient technologies in eLearning

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Abstract: AMBIENT LEARNING is a new market validation project exploring the applications and hardware needed in creating networked context aware environments for ambient services and testing them in the eLearning area.

Key words: AMBIENT LEARNING; eLearning; use cases

A recent European Survey report (Jane Massy, 2002) revealed some disastrous facts about eLearning: "61% of all respondents rated the overall quality of eLearning negatively - as 'fair' or 'poor'." According to recent studies by IT Skills Research Programme and consulting firm OvumHolway the take-up of eLearning in Europe has been rather slow due to a combination of numerous factors/barriers like fear of miss-investment, lack of time and expertise, inadequate accessibility and usability, failure to integrate eLearning with the work and life process or even inadequate low-quality learning content. The survey "Lifelong learning: a citizen's view" brings to the point the key main obstacles to lifelong learning: time and money. Exactly at these identified obstacles starts the new AMBIENT LEARNING project, merging eLearning objectives with new Ambient Intelligences opportunities. Using recently established technologies for enabling ambient intelligence and context aware services, its objective is to provide a pragmatic, easy-to-use eLearning service, which allows any time, any where and any how access to personalised, high quality learning content.

The service will be demonstrated along three use cases.

1. Busy professionals lack time for vocational training and therefore target articles out of scientific or professional magazines for learning. The AMBIENT LEARNING service will enable to structure and define personal training needs. Based on specific contexts (for instance driving to a customer) and personal interests the learning content will be

downloaded from scientific or industrial content providers to mobile devices and read with a Text-To-Speech engine.
2. Innovative software based solutions and applications are not widely deployed in European SMEs. This is mainly due to daily operation and lack of financial resources for affording consultants able to tailor these systems to their specific needs. The service will allow to deliver an interactive learning unit explaining system functionalities to potential customers. Moreover an interactive testing of the customers know-how will suggest context-based in-depth training or training repetitions.
3. Service employees on external duty, have often no possibility to join standard training activities or use state-of-the-art eLearning applications due to often changing environments (devices, networks etc.). The offered service will allow for context-based access to key learning units.

The developped LMS will provide complete Catalogue and Management functionality. The ability to list any online learning, event and any content type (electronic Books, SCORM-based learning objects, databases etc.) will enable an holistic one stop shop. The system is based on a service-oriented architecture (SOA) made up of components and interconnections that stress interoperability and location transparency.
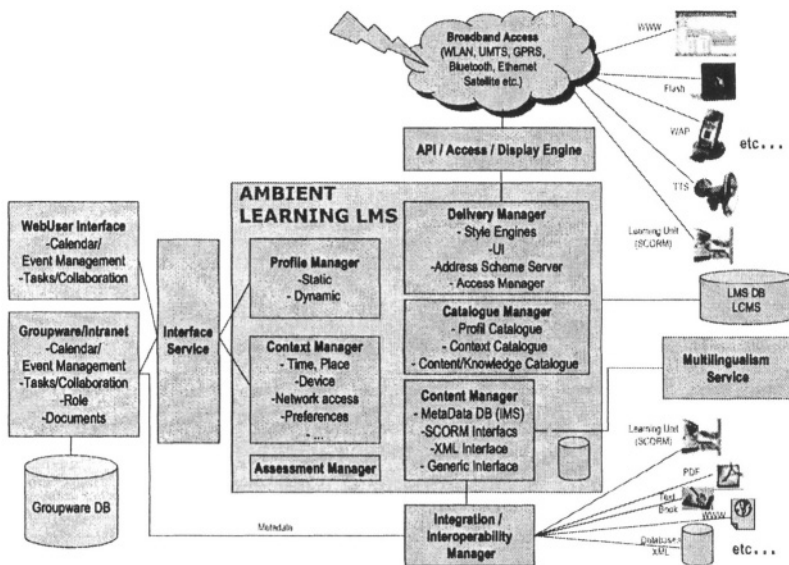

Figure 1. AMBIENT LEARNING architecture

Jane Massy - "Quality and eLearning in Europe", 2002
Office for Official Publications of the European Communities (Luxembourg) - "Lifelong learning: citizens' views" , 2003

THE EUDOXOS PROJECT

Teaching Science in Secondary Education through a Robotic Telescope

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Abstract: The Eudoxos project aims at using the possibilities the Internet offers in order to transform the classroom into a research laboratory. The project studies the applicability of the emerging technology in the school sector and provides a platform that allows the students to use the Robotic Telescopes of the Eudoxos National Observatory for Education and Research in the framework of their school curriculum. The robotic telescopes are installed in the Eudoxos National Observatory for Education and Research on the Ainos mountain of Kefallonia Island (Ionian Sea), Greece, performing night sky as well as solar observations.

Key words: robotic telescopes, e-learning environment, interdisciplinary learning

1.   PROJECT'S DESCRIPTION AND OBJECTIVES

The main aim for the Eudoxos project is to take advantage of the popularity of the subject of Astronomy and the attraction of the idea of using directly a first rate scientific instrument, in particular a high grade telescope, to teach students concepts and ideas of science, of a multidisciplinary nature spanning through the areas of mathematics, statistics, chemistry, physics etc. and of cource astronomy, astrophysics and cosmology.

2.   PROJECT'S PEDAGOGICAL APPROACH

In new technology application of **Eudoxos project** supports the **pedagogical method of autonomous self-directing learning** and allows for a self-directed acquisition of skills to meet users individual communication and learning needs. A learner support is supplied through an on-line manual that acts as an **on-line tutor.** The on-line tutor serves as the guide to the students' work. Methodologically it is based on the learning scenarios and the lesson plans that have been developed in order to support the project's application.

3.   STUDENTS' ACTIVITIES

In the framework of the project a user-friendly **web based educational environment is being developed** in order for the telescopes to be operated via queue based scheduling by high school students and their teachers. The project's implementation includes **two cycles of school-centered work** in real school environments. For the first cycle an adapted curriculum have been developed around a solid educational framework that captures the main learning objectives of the project (observation of the sun, the moon, planets, galaxies, nebulae, variable stars, eclipsing binaries), while during the second cycle the students and teachers of the participating schools have the chance to design and perform their own projects by using the telescope (as for example the determination of the orbital elements of asteroids and other ambitious projects and experiments) from their own direct astronomical observations.

The pedagogical framework includes the necessary adjustements to the normal school curriculum, teachers training (on-line seminars and workshop) and support, development of lesson plans for the project's implementation in the classroom and development of educational material (conventional and electronic).

USING MULTIMEDIA IN E-LEARNING, A NEW ROLE FOR TEACHERS?

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Abstract: This document presents a general overview of a new role proposed for teachers who are in contact with the information and communication technologies for distance courses content creation: the teacher-developer role. To acquire this profile, we are developing at the Laboratoire Paragraphe (Universit_ Paris 8, France) and the Tecnológico de Monterrey Campus Toluca (Mexico) a software tool called HyperTectol that introduces guides and promote in the faculty the use of multimedia elements for the Learning Objects design and creation.

Key words: learning objects, teacher-developer, multimedia elements, course content creation, new pedagogy

1.   THE PROBLEM

Some authors consider that well-designed Web-based teaching systems can greatly enhance student learning, while decreasing the amount of time spent in traditional classroom lectures.

In face of those changes, we consider that teachers who are in touch with information and communication technologies should start getting involved with the use of multimedia resources in education. An adequate process would consist of an introduction for those teachers who haven't had any

previous experience in the domain of e-learning, which could then be gradually complemented until satisfactory immersion in the area is reached.

2.   HYPERTECTOL

At the Université Paris 8 we are developing an assistant tool for creating and authoring course content. Its target public are teachers with little or no previous experience in the area who want to work out their immediate needs, but, most important, who want to start a process of promoting multimedia-based culture for pedagogic content design.

Our tool is called "HyperTectol" and its goal is to introduce, guide and promote the faculty members to the use of multimedia elements for the Learning Objects design and creation for delivery through web.

Our research proposes a first step towards a new role called *the teacher-developer*, who has two main characteristics: 1) basic knowledge of how to create multimedia-based course content, and 2) domain expertise in his area of study.

We divided the said process into three stages or levels: beginner, intermediate and advanced. Each level offers faculty members different perspectives for using multimedia resources in online courses. Each of these phases also has a section that allows users to design, create and edit LO. Media types vary form one stage to the other, gradually increasing; starting with text, continuing on to images and sound and finishing with video and animation.

At this moment, we consider that the main limitations of Hypertectol are related to its interface, which is presented in English and the platform required is Mac OS X (10.2 or later). Coming versions consider XML technologies, French and Spanish interfaces, and an online version accessible from the Web.

A CONNECTIONIST APPROACH FOR ADAPTIVE LESSON

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Abstract: This paper investigates the use of computational intelligence for adaptive lesson generation in a distance learning environment. A method for adaptive pedagogical hypermedia document generation is proposed and implemented in a prototype called *KnowledgeClass*. This method is based on specialized connectionist architecture. The domain model is represented in a connectionist-based system which provides an optimal didactic plan composed of a set of basic units. The generated didactic plan is adapted to the learner's goals, abilities and preferences.

1.   INTRODUCTION

Intelligence in a Web-based learning environment (LE) is ensured with tools enabling efficient management of the available information. One of the important keys is the system capability to provide the learner with personalized, adaptive and effective teaching. Thus, our research is focused on the adaptive systems to accommodate diversity in the learner needs, abilities and preferred learning style. Towards this direction, this paper investigates the use of connectionist methods to support the lesson generation process.

For this personalized learning, two models should be built: the domain and the learner model. A connectionist-based structure for representing the domain model is proposed and interactions between the connectionist architecture and the learner model are described.

2.   THE INTERACTIONS FOR THE GENERATION PROCESS

The didactic decisions are made at the end of the knowledge evaluation and the identification of the learner preferences and the domain model consultation. The generation of the adaptive didactic plan concretizes the composition of pedagogical documents adapted to the learner profile. The basic idea is to use the learner and the domain models to extract and organize the knowledge in order to satisfy the learning goal. The generation process is carried out in three stages:

- Selection of the learning goal by the learner.
- Planning the content: selection of the suitable concepts for the learning goal.
- Planning the presentation : selection of the basic units hand-annotated and organized in didactic plan for delivering to the learner according to a teaching strategy defined by a learning style.

3.   THE CONNECTIONIST IMPLEMENTATION

Two Multi-layer Perceptrons (MLP) with one hidden layer are constructed to model the third stage of used information and the decision to make upon learner's understanding.

An artificial neuron calculates a function of all incoming values corresponding to the neurons outputs of the previous layer multiplied by the link's weights. In this neural net each output neuron in the output layer is assigned to a *basic unit,* while input neurons in the input layer represent the *concepts* related to the learning goal of the course. The used algorithm for training the MLP is called *'BackPropagation'* and it works by calculating the difference between the neural net responses upon input vectors and the desired outputs. The first neural network is used to select the appropriate (UB) for the learner in the first stage of learning. The input layer presented the concepts of the course, one neuron per concept. The input vector (VI) is a {-1,1} set where the values $VI_i=1$ indicates that the corresponding concept (c_i) is important to the learner and the values $VI_i = -1$ means that (c_i) is not. The (VI) values are set by the evaluation module for the pre-test phase. The second neural network intervenes when the learner don't succeed the post-test of the concepts. This later generates a vector of marks related to concepts called reinforcing vector (VR). The (VR) is used as input values for the second neural network, the output layer for selecting reinforcing documents called (UB).

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