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The Design and Implementation of a Networked Virtual Classroom: A case study in the area of Fluids Physics

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Abstract

The rapid expansion of Information and Communication Technologies opens new paths towards the implementation and delivery of Open and Distance Learning (ODL). More specifically, the development of Web-based communication and collaboration tools acts as a basis for the design and implementation of "Networked Virtual Classrooms" to support flexible educational and training systems. In this paper, we represent and analyse the design and implementation of a Networked Virtual Classroom (N.V.C.), through a case study in the field of fluids physics. We discuss the main characteristics of a Networked Virtual Classroom and we present the architecture of a networked information system, which can be used for its implementation. Finally, we present such a Networked Virtual Classroom through a case study: an Open and Distance Learning course, in the area of Fluids Physics, implemented in the Department of Primary Education of the Aristotle University of Thessaloniki, Greece.

Keywords: Open and distance learning; networked learning; networked virtual classroom.

Introduction

One prevalent characteristic of this century concerns the changes taking place in the social, labour and educational fields, which are strongly correlated with the rapid expansion of communication and information technologies. These changes redefine to a certain degree the qualifications of the human workforce, such as the need for continuous adaptation to specific knowledge and skills (Minoli, 1996). The traditional model of education based on the face-to-face mode of delivery seems incapable, by itself, of supporting such a need. Therefore, the use of current Open and Distance Learning (ODL) techniques is considered a good supplement to the existing educational system (Blunkett, 1998), by reason of their flexibility in mode of delivery and the effective adoption of technological solutions. The term "Open Learning" includes two different meanings: on one hand, it refers to criteria of access to an educational system (openness taken as equivalent to the idea of removing barriers to free access to education and training); on the other hand, it

means that the learning process should be time, place and pace-free (Trindade, 1993).

Recently, there has been a tendency to develop education systems that support Web-based forms of Open and Distance Learning, (Porter, 1997; Owston, 1997, Stamatis, 2000) which seem to offer effective solutions as far as cost and flexibility of education are concerned. It has to be stressed that this tendency often leads to systems that are poor from the pedagogical and didactic point of view (absence of a well organized learning scenario).

Today, the most successful term describing all the characteristics of Web-based ODL is that of Networked Open Learning (NOL) or simply Networked Learning (NL) (Banks et al., 1998; McConnel, 1999). It is used to cover all forms of educational provision with the following key features:

- People ('tutors' and 'learners') communicate using computers linked to networks
- Access to learning resources stored on computers linked to networks

It is also used to denote a paradigm shift in flexible learning where Information and Communication technologies and the Web in particular are used to facilitate new forms of learning, which are not only learner-centred but are also strongly based on collaborative learning scenarios (McConnel, 1999).

The implementation of a NL course presupposes the existence of a Networked Virtual Classroom, which functions both as a learning material data base as well as a collaborative platform for tutors and students. Along with the first approaches to implement such a virtual classroom came a number of definitions in the literature. Turoff (Turoff, 1995) considers a virtual classroom as a substitute for a building-based classroom and defines it as an electronic-based environment incorporating virtual working spaces with communication capabilities. McCormack and Jones (McCormack & Jones, 1998) define the virtual classroom as a Web-based environment with organizational, communicational and evaluation capabilities through which tutors and students perform learning activities. Given that at present the Networked Virtual Classroom is based on the Web, we consider that:

> "The "Networked Virtual Classroom" is defined as a didactic-learning environment that is based to a networked information system and supports synchronous and asynchronous collaborative processes among tutors and students".

In the next section, we define the main characteristics of the Networked Virtual Classroom, as they emerge from the requirements of all the factors involved in a NL course. These characteristics form the specifications of the networked information system on which the Networked Virtual Classroom is based. The architecture of the system and its implementation is presented in section three. In section four, we describe the function of the Networked Virtual Classroom through a case study: an open and distance learning course in the area of Fluids Physics which in our case was redesigned to be offered through the NVC. In the last section preliminary results regarding the implementation of the NVC are given and the impact of the proposed networked information system in delivering open and distance learning courses is discussed.

Main characteristics of the Networked Virtual Classroom

The design of a Networked Virtual Classroom is based on characteristics that are related on the one hand to pedagogic/didactic issues and on the other to issues regarding the support of the educational process at the technological and administration levels. The characteristics related to pedagogic/didactic matters concern the main factors involved in the educational process, namely students, tutors, learning material and didactic methodology.

From the students' point of view, due to the distance separating them from the tutor, all kinds of communication (synchronous and asynchronous) are important for their active participation in the learning process from any place, at any time and at their own pace (McCormack & Jones, 1998). This communication with the tutor, or with other students at a distance, may contribute to the achievement of a higher level of interaction and involvement. Other important aspects of the learning process in an open and distance learning system are the ability to choose subjects and the full access to multiple resources. In this way students can search and manage the learning material, are able to structure learning experiences and become active producers of learning and not passive consumers of information. Furthermore, the ability to take part in an on-line assessment procedure can offer them a precise view of their learning progress.

The tutor, for his part, also needs to have the ability to communicate in synchronous and asynchronous ways in order to interact with the students, guide them towards active participation in the learning process, solve didactic problems, provide support, evaluate and receive feedback from students' questions and thoughts deriving from their interaction with the learning material. In addition, the potential for communication and collaboration with other tutors or specialists in specific areas can lead to the formation of networks of specialists, who interact with and learn from one another. Another area in which the tutor is involved is that of organizing the class and the didactic methodology. Class organization here means administration support issues (e.g. registration, bulletin boards etc). The didactic methodology in a networked open learning environment cannot be based on knowledge transfer processes, but on techniques designed to encourage students to manage the learning material in the best possible way and to facilitate their interactions in the framework of a collaborative network. Finally, access to an on-line assessment process can provide the tutor with feedback concerning student misconceptions and alternative ideas that will lead him/her to make the necessary changes in didactic methodology and/or learning material.

As for the learning material used in a Networked Learning process, important factors are format (electronic), the inclusion (or not) of multimedia implementations (video, movies, pictures, sounds), the effectiveness of the navigation algorithm and its accessibility via the Internet. With respect to the administration of the learning material, important factors are the friendliness of the user interface environment, the continuous updating and the scientific validity of the information.

Regarding support for educational procedures at the technological and administrative levels, there are a great number of commercially available systems or tools; these can be classified in the following categories (Bratistis & Dimitrakopoulou, 2001):

- Course authoring tools with which one can construct the didactic material for the course.
- Course management tools or Instructional Management Systems that can be used for the organization and the administration of Networked learning courses. These may include tools and procedures for tracking students' learning progress, electronic student diaries etc.
- Knowledge Management Systems that are mainly course database systems offering facilities for storing, retrieving and managing course unit material.
- Virtual Learning Environments, which are integrated software systems for organizing and administrating the educational process. These environments combine the functionality of the communication medium (e-mail, bulletin boards, newsgroups) with the implementation of various approaches for creating, presenting and delivering the educational material.

During the past few years there has been extensive development of the so-called virtual collaborative learning environments (Bentley et. al, 1997), which incorporate administrative and teaching tools supporting distance learning and which can also accommodate learning material developed by any of the above-mentioned tools.

It should be noted that many technological systems for the delivery of networked learning are currently being tested, but the emphasis is on the technological rather than the pedagogical/didactic aspect. We believe that, in order to design a Networked Virtual Classroom, these two main factors have to be combined on such a level that they cover as many pedagogical needs as possible and the use of technological systems does not become an end in itself.

Taking into account all of the above, the design of an information system to support the networked virtual classroom has to be based the following requirements:

1. Flexibility, including:
   - Options of subject areas and fields.
   - Options of access and administration in multiple learning spaces.
   - Flexibility of knowledge generation
   - Flexibility in knowledge utilization and administration
2. Openness, giving opportunities for:
   - Geographical independence.
   - Open content.
3. Interactivity, with feedback capabilities that:
   - Permit tutor/tutor, tutor/student and student/student collaboration
   - Facilitate educator guidance of student's active learning.
   - Allow entry of all the necessary data coming out of students' interaction with the learning material as well as with other students, and thus facilitating the evaluation procedure.
   - Includes evaluation and self-evaluation systems.
4. Communication capabilities
   - Supporting synchronous and asynchronous modes of communication.

The Information System Supporting the Networked Virtual Classroom

An information system that will meet these requirements should support the following processes:

- "Student" Process: This is responsible for implementing all the necessary activities to support users-students in their interaction with the Networked Virtual Classroom. These activities include communication with tutors, access to the learning material, access to the administrative and evaluation process of the virtual classroom, etc.
- "Tutor/Mentor" Process: This is responsible for implementing all the necessary activities to support the tutor-mentor in his interaction with the networked virtual classroom, such as communicating with students, adapting and delivering the learning material, etc.
- "Delivery of Learning Material" Process: This is responsible for carrying out all searching procedures for the appropriate learning material, based on student needs, and for forwarding this material to students. It is also responsible for transferring information related to the evaluation process.
- "Evaluation" Process: This is responsible for supporting the evaluation and self-evaluation procedures and also for updating student portfolios with information about their learning progress.
- "Classroom Administration" Process: This is responsible for carrying out all the necessary activities related to the administrative/secretarial support of the networked virtual classroom as well as technical support for students and tutors.

Figure 1 depicts the architecture of the information model used for the implementation of the networked virtual classroom that includes these processes. The model also includes databases with learning material and information related to students' learning progress as well all necessary connections/links among them. The connections between processes refer to all possible data flows that take place among these processes. All these possible connections together with the description of the relevant data flow are given in table 1.

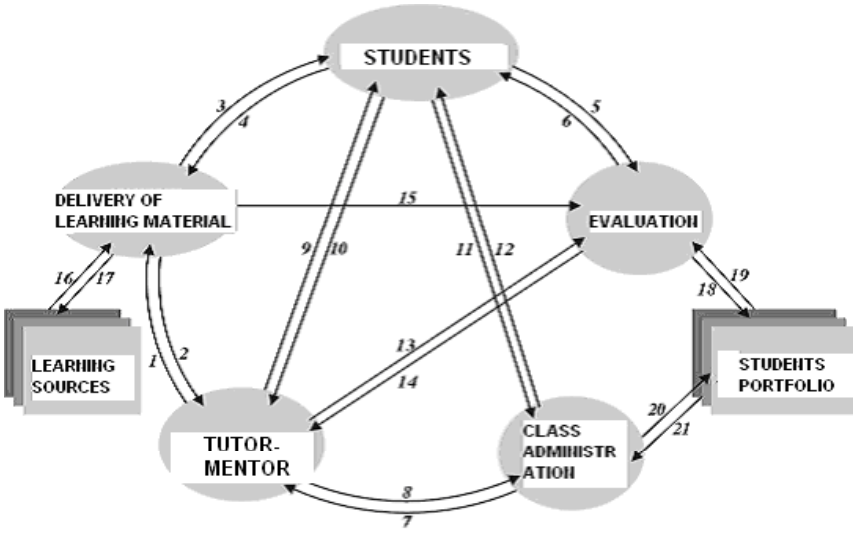

Figure 1. The architecture model for the Networked Virtual Classroom

*Table 1***.** Description of data flow among model processes

Link	Description of data flow
1	Searching requests for learning material from the tutor-mentor to the delivery system.
2	Feedback to tutor for the type of learning material that is searched through the delivery system.
3	Forwarding of multimedia learning material to the student's process.
4	Student's process, according to learning material request searches for specific material, through the delivery system.
5	Student's process forwards data to the evaluation process registering student's activities regarding the use of learning material and participation in learning activities.
6	Feedback from the evaluation process to students, with data regarding their evaluation and self-evaluation.
7	Feedback to the tutor-mentor process with data from the administrative-secretarial and technical support system.
8	Tutor-mentor process requests information from the administrative-secretarial and technical support system.
9-10	Support for communication between tutor-mentor and students processes, which can be established via synchronous and/or asynchronous means.
11	The administrative-secretarial and technical support system provides feedback to students with data relating to administrative and technical matters.
12	The students process requests data from the administrative-secretarial and technical support system in order to address operating, administrative and technical problems.
13	The system, at the request of tutors-mentors, detects data inside the evaluation system concerning student-learning performances relating to the learning procedure.
14	The evaluation system gives feedback to the tutor-mentor process with data concerning student-learning progress.
15	The delivery system sends data for the content of learning material to the evaluation system, giving all necessary information for entering student activities and behaviour.
16	Retrieval of multimedia learning material.
17	The learning material delivery system is, at the request of students or tutors-mentors, asked to locate learning material.
18	The evaluation system stores all information regarding student learning behaviour in student's portfolio.
19	The system offers the ability to retrieve data from student's portfolio for processing by the evaluation process.
20	The system updates student's portfolio with data related to course administrative information.
21	Data send from student's portfolio to the administrative-secretarial and technical support system.

It has to be emphasized that no specific didactic methodology is suggested within the model, since this is the subject of "the course-delivering scenario". On the other hand the model is generic enough to support many such didactic methodologies. The model described above can be considered as an enrichment of the I.E.E.E – L.T.S.A (IEEE LTSA, 2001) model for learning systems. The main extension concerns the addition of the administration process, which is considered crucial, especially if the system is to be used by tutors and students with minimal knowledge of information and communication systems. Other modifications include use of learning resources, the delivery of learning material system and redefinitions of working interactions among processes, in order to satisfy all criteria discussed concerning the requirements of the networked virtual classroom.

In order to implement the information model of the Networked Virtual Classroom, **BSCW** (**B**asic **S**upport for **C**ooperative **W**ork) software (http://www.bscw.de) was chosen as an appropriate tool. The decision for choosing BSCW among other software packages (such as Blackboard, WEBCT and TOPCLASS), (Landon et al., 1998) was based mainly on the following criteria:

- The software provides a highly interactive platform, based on the notion of shared workspaces, which allow for the implementation of collaborative learning processes
- It is based on an open architecture, providing tools for synchronous and asynchronous communication, while at the same time permitting the incorporation of any relevant third-party tools and all types of multimedia courseware material
- It has a flexible administration sub-module
- It runs on top of any www browser and it is free of charge for educational institutions

All the processes of the model presented earlier were implemented using shared workspaces (Paraskevas, 2001), with the BSCW user interface acting as a communication bus (see figure 2) between them, the learning resources and the student's portfolio. All data flows between processes in the model run through this communication bus.

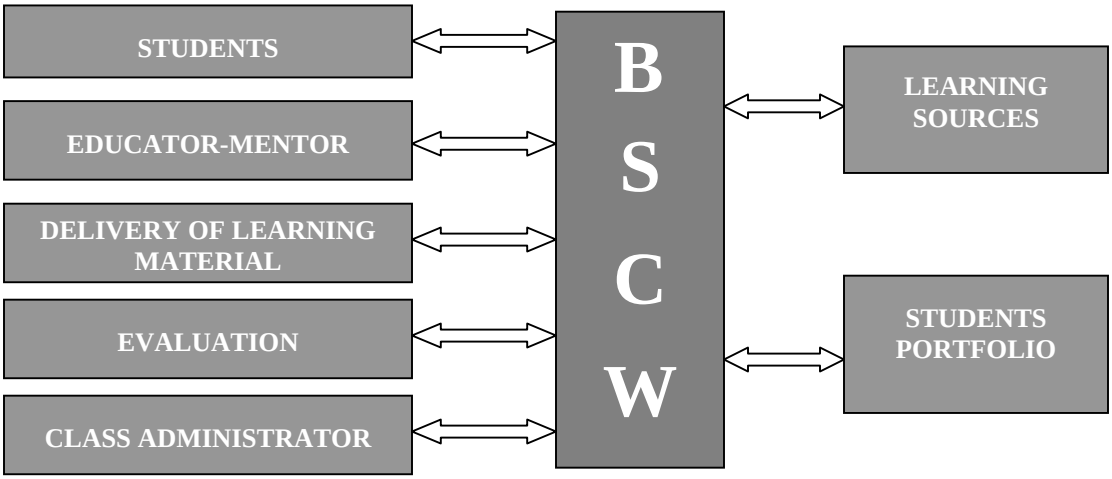

Figure 2. The Networked Virtual Classroom information model by the use of BSCW

The Function of the Networked Virtual Classroom

A Networked Learning course in the area of Fluids Physics, briefly (N.L.F.P.), was implemented as a case study and offered through the Networked Virtual Classroom. It was offered to a trial group through the Department of Primary Education of the Aristotle University of Thessaloniki, Greece. The course was based on an open and distance self-learning package that was initially developed using "traditional" open and distance learning techniques, (Molochides & Psillos, 2000). The package includes instructional text, enriched with drawings, photos and moving images, followed by simple material for performing experiments. Based on the package structure and content, an electronic equivalent was developed to be offered as a networked learning course through the Networked Virtual Classroom.

The implementation of the networked learning course and its delivery through the Networked Virtual Classroom using the BSCW software was accomplished in the following phases:

Phase 1: The adaptation of the self-learning package as a networked learning course

The NL course adaptation of the self-learning package includes:

1. Introductory text with package information.
2. Detailed instructions for the trial group so that they can navigate and easily search inside the learning material.
3. Guided texts which included:
    a. Work sheets and activities for each lesson, with which the trial group are expected to practise and interact with the learning material as well as to understand it better.
    b. Self-evaluation questions for each lesson.
    c. Answers to the self-evaluation questions.
    d. Tables with the material necessary in order to perform the various activities included in each lesson.

Moreover, for better comprehension, the learning material was enriched/illustrated with pictures, video, sound, as well as hypertext and links wherever this was thought necessary.

Phase 2: The creation and organization of shared workspaces.

Based on the networked information model shared workspaces were organized that included (Figure 3):

- A shared workspace for the tutor-mentor, to accommodate information related to their communication with students and other tutors and to facilitate the delivery of learning material, etc.
- A shared workspace for students, to accommodate information related to communication activities with the tutor and to facilitate access to the administrative and evaluation procedures.
- A shared workspace for class management, which includes data related to secretarial and technical support.

- A shared workspace for course material, which includes the learning material and other learning resources of the package.
- A shared workspace for the evaluation, to accommodate student portfolios with data concerning the evaluation of their learning process.

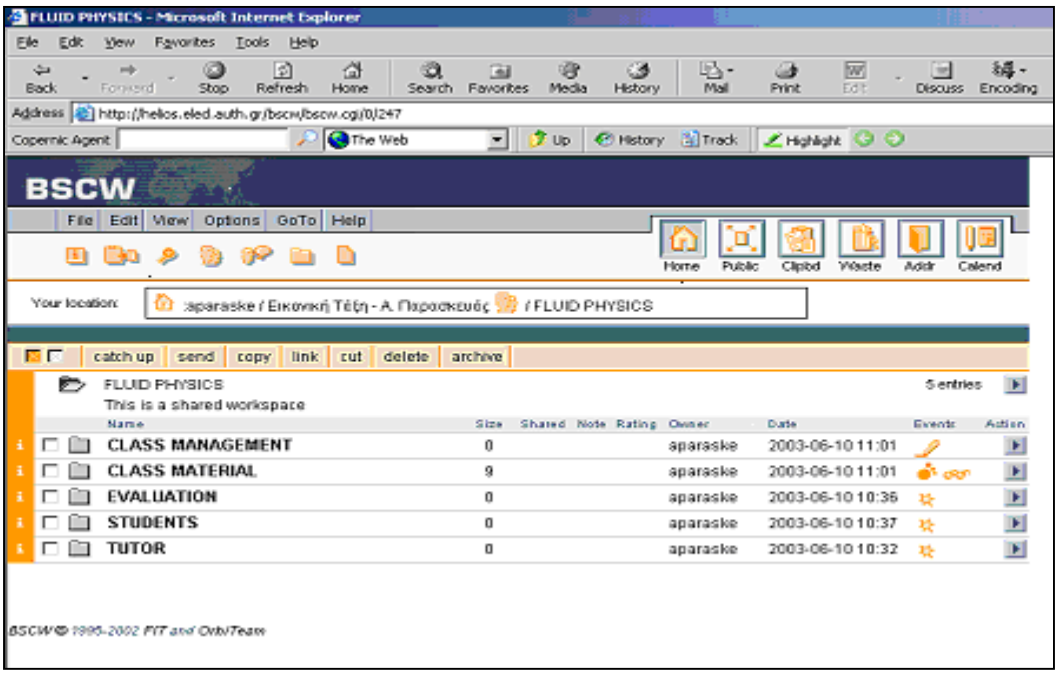

Figure 3. Shared Workspaces in the Networked Virtual Classroom

The shared workspaces allow the members (tutors and students) of the virtual classroom:

- To own and administrate a personal virtual space with capabilities of storing, updating and deleting data. To choose the graphical interface for their working environment, (e.g. Internet Explorer, Netscape Communicator, or the BSCW JBROWSER**).**
- To form groups or subgroups according to the needs and particular type of their collaboration.
- To designate the members with whom they wish to collaborate synchronously using net meeting and videoconferencing or asynchronously via e-mail.
- To have access to the recorded (by the BSCW software) data containing all the activities that took place in their private workspace and access to their portfolio in order to check their learning procedure.

The creation of individual workspaces was thought to be necessary in order to avoid data confusion and make searches by the members of the virtual classroom easier.

Phase 3: Registration of members in the Networked Virtual Classroom

We proceeded to a trial member registration in the Networked Virtual Classroom, comprising in-service teachers and three university tutors. A total of 15 members were registered. The registration procedure was based on two stages: first the BSCW sent an electronic invitation via mail to each candidate, asking them to fill in and identify their user name and password, and then the administrator of the virtual classroom arranged for the final level of authorizations (Figure 4).

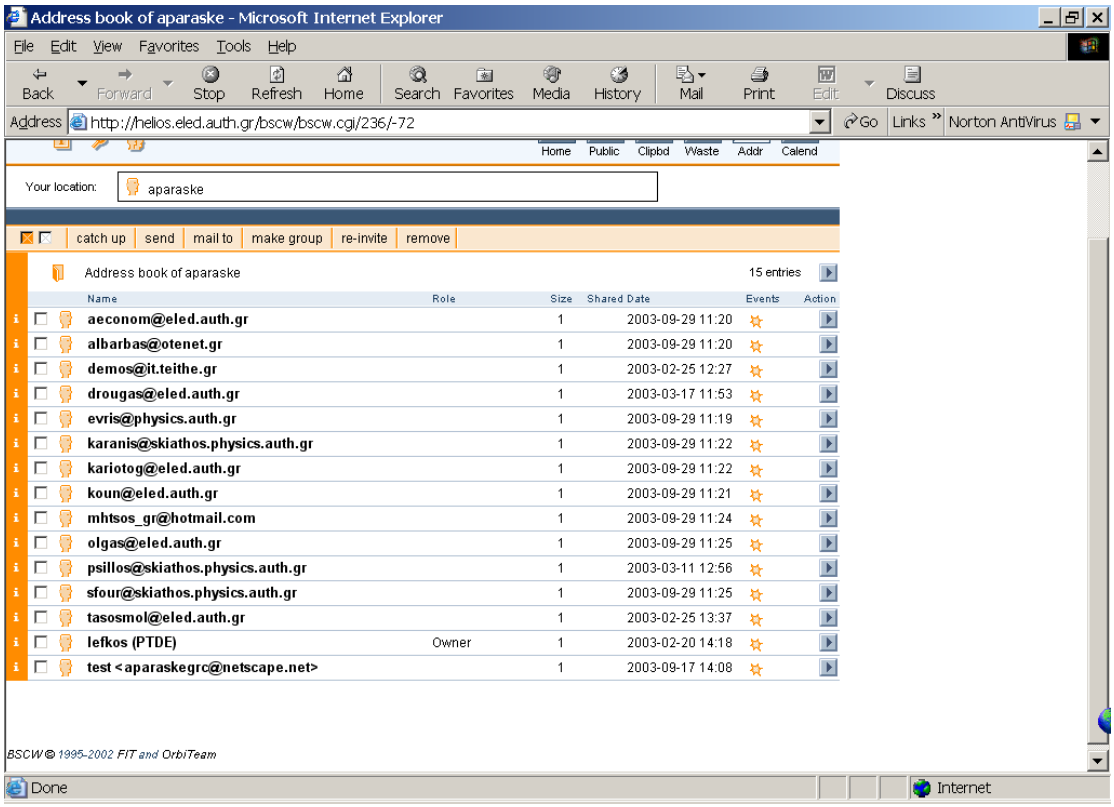

Figure 4. Members of the Networked Virtual Classroom

Phase 4: Course delivery via the Networked Virtual Classroom.

Course delivery via the Networked Virtual Classroom includes, individual or team access of the package learning material, sequentially or by selection according to participants background. After having downloaded and completed the lesson activities students filled in the evaluation exercises of the package. The output produced by the students engaged in the N.L.P.F., the evaluation exercises or anything else thought to be important can be uploaded via BSCW to a shared workspace where it is accessible to other members. There are options for students, which they may use to add notes and questions or change documents. By taking into account the remarks of other members, one student or group of students can re-negotiate the produced documents in order to forward them for evaluation (figure 5).

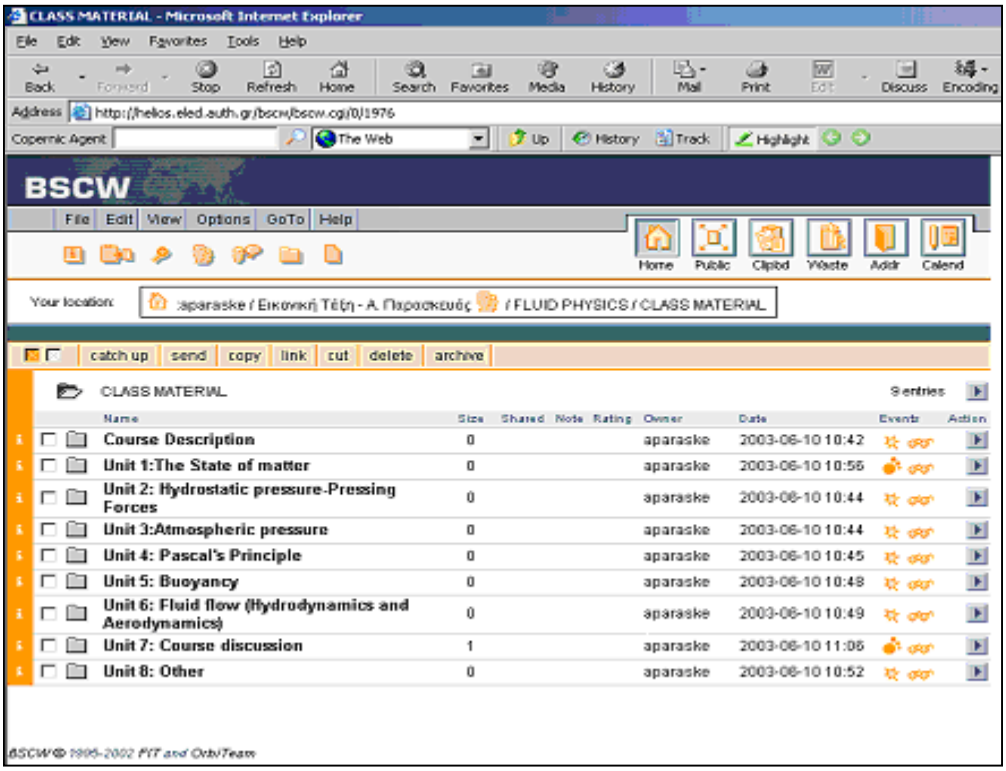

Figure 5. Lesson material in the Networked Virtual Classroom

Phase 5: Communication among tutors and students.

In the above process the system offers students the option of communicating with one another or with the tutor in a synchronous way using chat rooms (figure 6) or net meeting or by videoconferencing and/or an asynchronous way via e-mail. With these forms of collaboration, students have the opportunity to understand the learning material and solve questions on the learning-didactic procedure.

Preliminary Results of running the Networked Learning course

The Networked Learning course on Fluid Physics (N.L.F.P.) was initially delivered to the trial group. At the end of the course a questionnaire was given to all members of the Networked Virtual Classroom (trial group, tutor and course administrator) regarding the functionality of the NVC and the N.L.F.P. course. The preliminary results of the networked learning process as found based on these questionnaires and discussions with the members of the NVC could be summarized as follows:

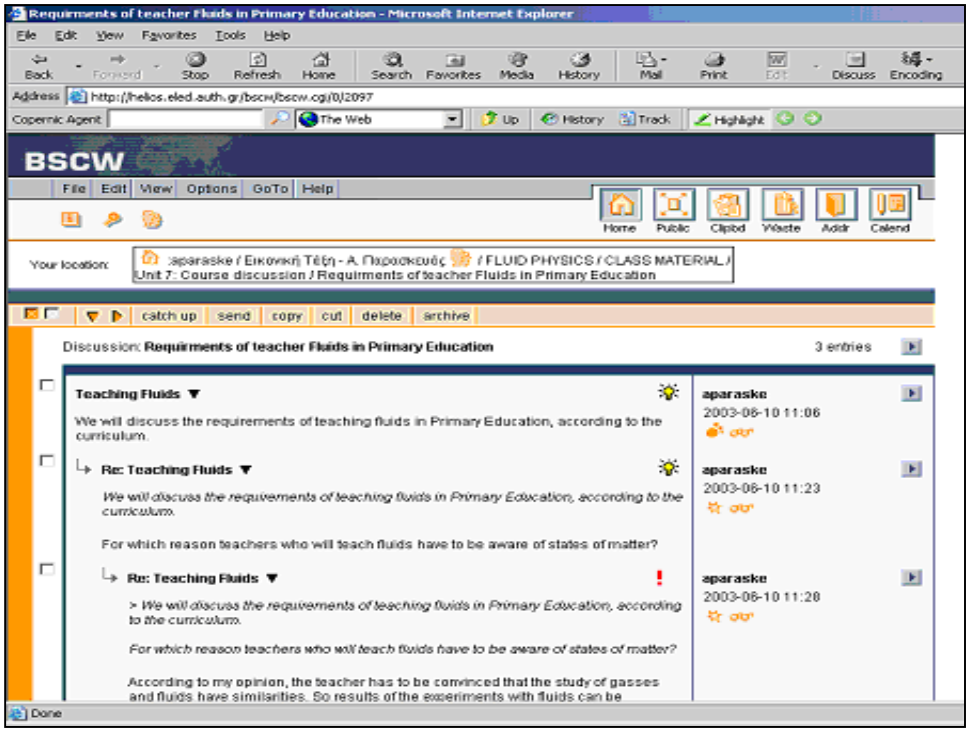

Figure 6. Synchronous communication among students of the Virtual Classroom

From the educator/mentor point of view:

- The information system developed and implemented by the use of BSCW for the NVC, its working interface and tools provided for learning material transfer are considered appropriate. Thus hypertext, photos, pictures and a digital video that assisted students in understanding the specific thematic chapters were uploaded successfully.
- The use and transfer of learning material over the NVC offers the reassurance for continuous delivery of scientific proved material with the minimal cost and working effort. In addition, the communication tools were also rated as satisfactory, although a design tailored to a collaborative environment would be preferable.
- Last the activity recording tools of the BSCW- can help the tutor, evaluate to a certain extend students' learning progress and, if necessary, redefine the learning scenario.

From the administrator point of view:

- The implementation of the class administration process of the NVC showed the importance of the supporting role of the administrator, which seems to relieve the educator/mentor of responsibilities that make his job difficult in such ICT supported learning environment.
- BSCW included all necessary tools for the proper function of the server on which the NVC was installed. Its main advantage was the communication function with the software programmers in the research centre in Germany, for the solution of technical problems (technical feedback).

From the student's point of view:

- The electronic distribution of learning material over BSCW seemed to give flexibility to students in terms of time, pace and learning styles. They were able to work alone or collaboratively with peers.
- In order to fulfil the activities of the learning material, students used the communication tools (synchronous and asynchronous), which can be rated as satisfactory, in order to establish communication with the tutor and with peers. This procedure assists them to collaborate with peers in order to discuss and find answers for the package activities or to receive support from the tutor in order to proceed successfully in the learning procedure.
- The uploading of scientific proved material, electronic distribution over the BSCW interface of the NVC and tutor support through synchronous or asynchronous communication seemed to involve students immediately with the learning process without wasting time dealing with technological or learning problems.
- The BSCW user interface initially was not considered particularly friendly, but with minimal effort and guidance was easy to use. The main difficulties faced by the students (due to their background they had no advanced ICT skills) had to do with the navigation procedure through the learning material, the creation and the uploading of new files.

Conclusions and Future Work

Information and communication technologies (ICT), properly used, contribute to the quality of Open and Distance Learning. Nowadays flexible open and distance education frameworks, using the Internet and the World Wide Web as a general platform, are developed that are based on the collaborative approach to learning. The development of software tools that support Web based collaboration of users (referred to by the term groupware) contribute towards this goal.

This paper presents such an effort: to design and implement a Networked Virtual Classroom in order to deliver networked open learning courses. The pedagogic, didactic and organization needs (both administrative and technological) of all factors regarding the Virtual Classroom were discussed. Based on these needs a networked information model was suggested which can act as a framework for the implementation of an NVC. Such an NVC was implemented by the use of the BSCW groupware package and was tested trough the delivery of the Networked Learning course on Fluid Physics (N.L.F.P.)

Comparing the Network Virtual Classroom approach with the typical Open and Distance Learning one, a number of benefits were identified which prove the positive effect of the ICT based approach. These benefits are:

- Better access to part of the learning material, which can be updated easily and continuously.
- Better access to multiple resources over the net,
- Possibility of support through frequent communication with the tutor.
- Possibility for a collaborative approach to learning through synchronous and asynchronous communication with peers taking the course.

At this first stage our basic aim was to evaluate the functional aspects of the Networked Virtual Classroom. The N.L.F.P course is now ready to be used by groups of teachers. In this way a more systematic "long test bed" will give us the opportunity to evaluate the course with focus on learning results, didactic methodology and the pedagogic point of view. Based on this evaluation we will also be able to refine the specification of the Networked Virtual Classroom and update the networked information model supporting it.

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