PROJECT BASED LEARNING IN INTERNET

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Abstract - Project based learning (PBL) is a well-established reality in engineering education. Internet technologies enhance traditional PBL by offering new resources, tools and services. They add, for instance, the possibility to define distributed projects, where project parts are developed by geographically distant persons or teams. The paper presents the characteristics and the results of NetPro, an EU-supported project that has created models, methods, tools and learning materials for network-based project learning (NPBL) in engineering education. The models applied are those of engineering work practice, adapted to an educational context. NetPro student teams may form cross-institutional learning communities that share and peer review project deliverables and interact in special interest group discussions. Running pilot projects tests NetPro methodologies and tools. The paper describes in some details the pilot supporting first year courses in the field of digital electronic design.

Index Terms - Cooperative learning, project and problem-based learning, teamwork, web learning environment, digital electronics, educational tools, simulation.

PROJECT BASED LEARNING

The development of information and communication technologies has changed work methods and processes in the field of engineering. More and more tasks are accomplished in a collaborative way, often by geographically distributed teams. These new working methods require proper training and appropriate skills, especially the ability to work in virtual environments.

Engineering curricula if, in one hand, have adjusted their contents to support the new technologies, have remained, on the other hand, very much traditional in the way they implement the educational processes. Curricula, indeed, still based on courses, provide fragmented pieces of knowledge and skills. From a methodological point of view, it seems also that the paradigm of transmissive, instructional pedagogy, focused in the student-teacher interaction, is alive and well.

The maturation and diffusion of e-learning technologies has raised the hope for the development of learning methods and infrastructures more adapt to develop the skills needed in today’s workplace. Major efforts have been put on the development of web-based virtual learning environments and tools for education and training [1], [2]. However, most of the products and tools available are still based on classical pedagogies. Their main functionalities are the management and distribution of learning materials, synchronous and asynchronous communication, and progress tracking and reporting.

Project Based Learning (PBL), a common form of collaborative pedagogy in engineering education, is a teaching/learning model that involves students in problem-solving tasks, allows students to actively build and manage their own learning, and results in students-built realistic deliverables. Students work on concrete tasks and produce realistic products. The underlying principle is the assumption that learning occurs during these unstructured, complex activities. Ways of implementing and using PBL are diverse and multiple. They differ by the complexity of the projects, their combination with classical lecture-based methods, the role of the teachers and students in planning these projects, and the group or individual approach. Teachers and students activities in PBL context are different from those in classical pedagogies.

THE NETPRO PROJECT

The innovative approach developed by NetPro [3] integrates traditional PBL into a network based learning environment. The NetPro framework provides process models with specific project learning phases and actors with their roles, methods for collaborative learning, resources to support project implementation, and tools to build a Web-based learning environment that supports project learning [4].

In Netpro, a project is considered as a course. Teachers define the objectives, content, activities, working method, tasks, deliverables and assessment strategy of the project. A project is divided into tasks, each task consisting of certain activities and resulting in creating deliverables. Learning materials, guidelines, and templates that help students to complete tasks are provided. Students are organised into groups and every group carries out a project. Pedagogical activities such as peer reviewing, group discussion, peer coaching and self/peer assessment can be set up by teachers to enhance the learning effectiveness of the project. Groups of students plan their work, complete the scheduled tasks, and produce deliverables. A deliverable can be any kind of document (e.g., engineering design, progress report…) or other products (e.g., software programme). These deliverables are shared with their peers locally or in an international learning community. Groups are asked to
review work produced by their peers working on similar topics and provide feedback to authors. This activity is done using guidelines created by teachers and result in filling-in peer-review questionnaires that depend on the nature of the deliverable and the topic. Discussion forums between reviewing and reviewer groups allow them to justify decisions and explain feedback. This allows students to develop a good judgement of quality and to learn from the errors and experience of their peers. Peer coaching is another activity being experimented. Senior students act as coaches for junior. They provide them with assistance and support during the project work.

**NETPRO TOOLS**

In order to implement the PBL approach described above, NetPro fully developed a set of tools targeted at the students and teachers. They allow teachers to manage project work and students to complete their project learning activities. These tools are organised in a database application accessible from the web.

The teacher tools allow the creation of new projects, by providing the following functions:

- Create, delete, modify a project structure (called project deliverable centre: PDC)
- Define tasks and deliverables for a project
- Create, delete, modify student groups for a given PDC
- Provide groups with work space and communication tools
- Link guidelines, templates, learning materials to tasks and deliverables
- Link peer review guidelines and forms to deliverables and tasks
- Assign groups for peer review
- Set up peer assessment scheme or view its results
- View work progress for all groups
- Create discussion forums
- Set up peer coaching

The student tools allow the following activities:

- Visualise work progress table (called PDC table)
- View guidelines, templates, learning materials related to tasks or deliverables
- Edit group details
- Upload or link finished deliverables
- Download or view other groups deliverables
- Fill in a peer review form to give feedback to peers
- Take part in a discussion forum
- Jointly edit a document with group members
- Seek peer coaching and communicate with coach

**Tools installation and resources needed**

The NetPro tools are interactive database applications that are used through a standard Web browser. User does not need any knowledge of Web authoring or special tools to use the applications. The NetPro tools can be easily linked into any Web based learning environment that the teacher may use. They are implemented on Apache Web-server, database is implemented in mySQL, programming in PHP and Java languages. All of these components are available on several server platforms, such as Linux and Windows.

Currently the NetPro system is installed in a server in Espoo, Finland and accessed remotely by the project partners. The project has started the preparation for the large-scale transfer activity by prototyping the concept of "NetPro Learning Communities". The long-term goal is to develop a self-funding organization for promoting and developing project-based learning on a wide scale. We expect to release the portable version of the software before the end of 2003.

**THE PROJECT DELIVERABLE CENTRE**

The Project Deliverables Centre (PDC) is the core component of the tools. It has two primary purposes: to support knowledge sharing between students, and to ease the tutor's workload in high-level project management. PDC provides a convenient way for sharing all the public project documentation within the learning community.

The main view of the PDC is a graphic that shows which items have been delivered, using a coloured-smiley metaphor (Fig.1). The course supervisor, using the Admin view, can create, modify and delete project teams, and define deliverables with deadlines. As deliverable specific resources, the supervisor can upload guideline and template documents that are then available in the student view. When a new student group is created, the system sends a computer-generated email to the student project manager giving the identity and password for access to their record, and other operational details. The teams may develop and maintain their own project site on a NetPro server, or produce their sites with any tools that are available for them and then link the public deliverables into the PDC by providing the URL. Another option, convenient for using PDC for managing reports of laboratory courses, where there is no need for project management and communication methods supported by the project site concept, allows direct uploading from the web. When this option is selected, no other web server is needed for storing the deliverables.

Students maintain the PDC by logging in with their group password. After logging in they can update their group’s data, upload deliverables, and do specific learning activities specified by the course supervisor using the different card views provided. Reviewing other groups’ work can enhance the learning experience of project students, for both the reviewer and the reviewed. After the designs have
been completed and documented, the groups can do peer reviews. In this process they can observe different approaches to the same problems and evaluate their benefits and drawbacks, so that all the groups can learn from each other’s work. The course supervisor creates on-line forms that the students use when doing the peer review. After the peer review form has been created and linked to a deliverable, the supervisor assigns the peer review responsibilities between teams within a PDC or between teams in different PDCs. It is thus just as easy to review the work of a group in a remote institution as it is within one’s own site. After a deliverable has been published in the PDC, it can be peer reviewed simply by filling in the online form. Teams can access the forms, after logging into the PDC, by clicking the Peer review tab. The project teams can also easily access the peer review report made on their deliverable in the PDC peer review view.

The NetPro learning environment also includes facilities for the students within a group to assess one another’s contribution by awarding grades against a given set of criteria. The course supervisor can create on-line forms that the students use when doing the self and peer assessment. A form can be used in multiple PDCs and also shared by teachers. After the project is finished, the team members can do the self and peer assessment by filling in the form assigned for them. Each student can see whether their colleagues have completed this task, but the values awarded are concealed until everyone has done it. Supervisor can view the peer assessment results at any time. The view shows how the individuals have rated each other and also the figure for relative performance of each team member. It is then up to the supervisor to decide how to use these data.

Each project has available one or more open discussion spaces, called Special Interest Groups (SIGs). They are sort of bulletin boards where course participants can read and write messages. Messages posted on SIGs are public: every project member can read and reply to them.

**NETPRO PILOT COURSES**

During the project’s life, four streams of pilot courses have been organised to test and validate NetPro method and tools. The topics of these courses are the following:

- Electronic Engineering
- Software engineering
- Multimedia Authoring and applications
- Interactive Web applications

In the final part of the paper we provide a short description of the Electronic System Design pilot course, i.e. the one organized and conducted by the first two authors.

**FIG. 1: STUDENT VIEW OF APDC OF AN ELECTRONIC PROJECT**
CO-OPERATION ISSUES IN NETPRO

An important characteristic of the NetPro courses is that project groups can be distributed over different academic institutions and countries. A course may have teams from more than one institution and more than one nation [5] while teams themselves could be inter-institutional and international. The issue of co-operation between the different actors is therefore extremely important in NetPro. In the following, we discuss it at three different levels: the institutions organizing the courses (i.e. the pilot sites), the project teams and the team members.

Co-operation between pilot sites

The immediate goal of the co-operation between pilot sites is to provide learning tasks that are meaningful for students from different schools, independently of their local arrangements. Obviously, a long-term result of such joint learning activities will be a further step of a most welcomed and long overdue process of integration and convergence of methodologies and programs within the institutions of higher education in the EU.

In fact, most European universities follow similar curricula in the engineering field so in principle it is possible to have joint activities. However philosophies, working practices, curricula and schedules at the partner universities differ considerably. The project has therefore identified common areas of subject matters in information technology and the pilot courses have been designed around them.

Each pilot site is responsible of organizing the project activities locally in the way that fits its curriculum and local teachers and tutors take care of the teaching related to the project. Pilot partners share materials and methodologies and develop common guidelines, templates, peer review forms and other required materials for their projects.

Experience has shown that full cross-institutional co-operation as described above is difficult to implement. We have found out that other, lesser forms of co-operation are quite effective and easier to implement. It has become customary, for example, to share projects assignments and related learning resources with other pilots running in later times in partner sites.

Co-operation between project teams

Co-operation between teams involved in a common project starts with the project assignment and the consequent public discussion in the SIGs. After the publication of the project deliverables, which in Netpro are public and therefore visible to all teams, co-operation continues with peer review.

Reviewing other groups' work can enhance the learning experience, for both the reviewer and the reviewed. In this process they can observe different approaches to the same problem, so that all the groups can learn from each other’s work. In line with NetPro philosophy, the team activities are independent from the physical location of the members and take place through the proper tools.

Co-operation between team members

Co-operation between team members is essential for the development of the project and, traditionally, it happens through face-to-face interaction. In NetPro, the Project Site, a Web based communication centre and archive, allows its de-localisation. With the Project Site tool, teams can create and maintain interactively a Web site on the NetPro server, to support their project management and team work. No knowledge of HTML authoring or ftp usage is required.

The Project Site acts as repository for resources needed to carry on the work and project deliverables and, furthermore, it offers educationally oriented groupware features, such as shared group workspace, collaborative authoring and annotation of group documents.

Other project management tools available are: an interactive project log, a meeting memo and a project status tool. Audio and video communication tools are included, to support virtual teamwork.

NETPRO IN ELECTRONIC ENGINEERING

The student projects in the Electronic Engineering pilot courses apply the NetPro methodology and tools in the field of education in electronics. The basic philosophy underlying their design and organisation has been not to adapt our teaching to the characteristics of NetPro but, instead, to use it to fit our pedagogical needs. As a consequence of such approach, in order to accommodate different students’ levels, skills and motivations, we tried a wide variety of pilot course formats, from simple projects given as laboratory assignments to more complex tasks. Projects were designed either to serve as a support of a traditional course or to replace completely lectures with project-based activities. NetPro tools were used accordingly to the pedagogical needs, with the results that many courses did not employ the full set of project’s tools.

The organisation of a pilot course depends very much on its nature and level. Simple projects are designed to support introductory courses of electronics, usually by coordinating and following the laboratory activities [6]. This kind of projects takes fully advantage of the learning environment, developed specifically for digital electronics, which is described in the next paragraph. By comparison with the traditional paper delivery of laboratory reports, NetPro tools provide a considerable help in streamlining the management of a large number of project teams.

After completing a project of the first kind the student is expected to be able to:

- Design combinational, arithmetic and sequential digital circuits (the latter as Finite State Machines)
- Analyse and test digital designs with the use of simulators
- Understand the principles of electronic CAD (Computer Aided Design)
Use a remote electronic laboratory controlled through Internet.

More advanced projects [7] are organised to develop skills immediately usable in the real world, by stressing the use of professional design, simulation and synthesis tools and, at the same time, emphasising the cooperative nature of project work, strengthening the skills needed in project management, project documentation (definition, plan, report), and project communication (internal, external, face-to-face, Internet-mediated).

With the term “learning environment for electronics” we designate a set of tools and resources that are specific to the subjects of the projects and provide to the students a technical support for their project work.

The learning environment for digital electronics is built around three main components:

- The Digital Electronics Education and Design Suite (Deeds)

- Interactive learning material and solved problems for Digital Electronics

- Internet Shared Instrumentation Lab (ISILab)

**DIGITAL ELECTRONIC EDUCATION AND DESIGN SUITE (DEEDS)**

Deeds is a simulation environment for digital electronics that helps students in acquiring theoretical foundations of the subject, analysis capabilities, ability to solve problems and practical synthesis and design skills. The tools are characterized by a “learn-by-doing” approach. Deeds covers the following areas of digital electronics: combinational logic networks, sequential logic networks, finite state machine design, micro-computer interfacing and micro-computer programming at assembly level.

The tools are fully integrated together: design and simulation of complex networks including standard logic, state machines and microcomputers are therefore possible.

**FIG. 2: PARTIAL VIEW OF THE DEEDS. THE ASSISTANT HELPS LEARNERS TO SIMULATE A DIGITAL CIRCUIT**

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The Fig. 2 shows a partial view of the suite: in this example, the Digital Circuit Simulator (d-DcS) is used to simulate a synchronous binary counter. On the background the Deeds main window and, on the right, the Assistant browser, that guides the student along the laboratory session.

The Deeds and related learning materials can be downloaded from its web site [8].

**INTERACTIVE LEARNING MATERIAL AND SOLVED PROBLEMS FOR DIGITAL ELECTRONICS**

With Deeds, teachers can provide tutorial materials to support projects’ development, in order to suit the specific pedagogical needs of their courses. In introductory level projects, the Assistant browsers are used to provide help and guidance to develop the projects. The Deeds lecture space can be composed with any HTML editor, completed by a helper application that facilitates the linking of the editors and simulators’ commands to the lecture’s text.

**INTERNET SHARED INSTRUMENTATION LAB (ISILAB)**

ISILab [9] is a test and measurement bench composed of remotely controlled instruments through Internet. The purpose of ISILab is to introduce real-world (not simulated) laboratory experiences in the context of the NetPro projects. The device under test will be connected to the bench and therefore will be accessible to all the remote teams. The experimental set up can be distributed in different real laboratories, spread on a wide area network, and controlled by local computers. Users can carry out experiments through the network and practice transparently to the real locations of the devices under test in a multi-user concurrent way.

**CONCLUSIONS**

The network-based learning environment enhances project work with Internet facilities. It is useful for local work, but is particularly convenient for inter-institutional and international co-operation. The feedback from students and tutors is generally favorable [10].

A final reflection is in order on the pedagogical effectiveness of the NetPro approach. The experience of the teachers involved with advanced projects has shown that the major positive influences for students are in learning project planning and management skills and the way that NetPro supports project process and communication.

As to the learning of the subject matter content, it is difficult to draw conclusions. Nevertheless, if we assume that PBL is a good approach when teaching engineering subjects, we can regard as an advantage the fact that NetPro makes possible and convenient to introduce PBL on a large scale.

**REFERENCES**


