Network Based Project Learning for Engineering Education

Authors:
Domenico Ponta, DIBE, University of Genoa, Genova, Italy, ponta@dibe.unige.it
Giuliano Donzellini, DIBE, University of Genoa, Genova, Italy, donzie@dibe.unige.it
Hannu Markkanen, Espoo-Vantaa Institute of Technology, FIN-02600 Espoo, Finland, hannu.markkanen@evitech.fi

Abstract — NetPro, a project of the Leonardo DaVinci European programme, supports project-based learning for engineering education through the Internet. The project has created models, tools and services to facilitate communication and collaboration between distant students, and to manage access and control of project deliverables. This new learning environment is a distributed system that facilitates sharing and peer reviewing of project deliverables, and interaction in special interest group discussions. NetPro teams form cross-institutional learning communities. The models applied are those of engineering working practice, adapted to an educational context.

Index Terms — Collaborative learning, student-centered learning, learning strategies, project and problem-based learning.

A NEW WORKING ENVIRONMENT FOR THE ENGINEER

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

Current stable technologies, accessible to educational institutions, do not support efficiently innovative pedagogical approaches, as based on models of collaboration used in modern working life. The NetPro [1] project (Network Based Project Learning in Engineering Education” supported by the Commission of the European Communities under the Leonardo DaVinci programme) has the purpose of filling this gap, by creating, testing and disseminating proper models, tools and practices. NetPro uses the paradigm of Project Based Learning (PBL), a practice widely used in engineering education; the idea of applying computer networks to PBL [2, 3] is not new, but there is a need for readily available tools to support student-centred PBL activities.

Furthermore, the addition of internet connectivity should not be seen only as a way to more widely distribute existing traditional approaches, but, also as a way to augment and evolve toward a true community of practice [4].

Pedagogical Models

The pedagogical models used in NetPro respond to the need for closer alignment of vocational training to working life. Such need is fulfilled by applying models of network based collaboration, such as knowledge management and sharing principles, used in modern work organisations. The models are therefore based on modern work practices, adapted into an educational context.

In NetPro, project learning refers to a methodology where part of learning is organised as a project. The main aim of a project is to give students an opportunity to apply in practise what they have been taught. Lectures, tutorials and laboratories are also provided to support the learning process. Project learning provides the student with a problem-oriented approach to engineering studies, and a context for the technology being studied. The learning project connects different studies and disciplines together in a way which mirrors real world engineering tasks. For most students, NetPro learning projects present the first opportunity to work as part of a team, to plan the work, and to make decisions as a team. Practical work and specific learning activities undertaken within the project provide not only the possibility to practise the technical aspects of engineering activities, but also to learn team working, management skills, planning skills, self-direction, responsibility and personal initiative.

Network based learning projects (NBPL) with geographically distributed teams increase the difficulty of planning and managing the students’ project work process. The NetPro project has adopted the concept of a project site to support team work. A project site is a Web based communication centre and archive for project artefacts. It includes educationally oriented groupware features, such as:
To enhance the learning of key concepts, specific collaborative learning activities within the project teams will be available. The NetPro framework provides a number of different methods that may be applied. After a deliverable has been completed and documented, the project teams can undertake peer reviews. In this process they can observe different approaches to the same problems, and evaluate their benefits and drawbacks, so that groups can learn from each other’s work.

Peer coaching refers to the assistance of a supportive peer who helps the learner to apply skills learned in classroom. This is organised specifically to support project work and the initiation of younger learners, although technical skills can be covered as well. Senior students act as coaches of the junior students.

Students may be asked to keep a learning log. It is a diary where a student writes regularly on his learning experiences during the project. The aim of the learning log is to allow the student to reflect on significant experiences associated with his/her learning.

Students’ self and peer assessment skills are also enforced. The learning environment includes facilities for the students within a group to assess each other’s contribution by awarding grades against a given set of criteria.

One important benefit of the NetPro approach is that the students are involved in the construction of their learning environment and materials - the results of the learning activities will be added to the learning environment for sharing with the peers and future learners. The Netpro project is developing methodology and tools to manage the increasing knowledge base by re-use and re-purposing of materials, and through discussions produced in learning projects.

Tools

The implementation of collaborative project learning, for distributed teams, cannot be implemented without appropriate tools to efficiently support both the students’ learning process and the teachers’ tasks. The development work carried out in the project is required because, in the market today, there are no tools available that would meet the needs of the education and training community. Instead, most Web-based course tools offer only simplistic pedagogical approaches. Commercial groupware packages are, on the other hand, too complicated and too expensive to be used in most educational and training institutions. The use of proprietary systems would also inhibit international collaboration in learning projects.

The Netpro project develops Web based software tools that support the implementation of the pedagogical models described in the previous section. The NetPro tools simplify the management of project-based learning activities, saving time for staff and students. The tools are, essentially, database applications that users can access through standard Web browsers. Even though the development is done in an engineering education context, the tools are discipline-independent. Three categories of tools will be available:

1 - Tools to support knowledge management and sharing approaches

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. The PDC provides a convenient way for sharing all of the public project documentation within the learning community.

With the peer review tool the course supervisor can create on-line forms which students use when doing the peer review. It is just as easy to review the work of a group in a remote institution as it is within one's own site - project teams simply fill in the peer review form available on the Web. The project teams can also easily access the peer review report completed for their deliverable.

The purpose of the NetPro peer coaching tool is to ease the organisation of peer coaching activity and to support the students and the peer coaches during the practical coaching process. It is especially useful in remote or cross-institutional peer coaching but is also helpful in organising the peer coaching locally. The peer coaching tool is based on a structured storage of knowledge and skills profiles of potential coaches. With the tool the instructor establishes the peer coaching process and allocates the coaches; peer coaches fill in their knowledge and skills profiles; student groups look for, and “subscribe” to, a peer coach; students and peer coaches communicate and carry out the peer coaching activities; peer coaches record and monitor the coaching actions.

Developing a course based on the NetPro project learning approach requires a considerable amount of work. To facilitate the reuse and sharing of completed NetPro learning units, the system provides a re-use tool to archive the contents of each unit (assignments, learning materials, project deliverables, peer reviews, SIG discussions). While archiving, the reuse tool allows teachers to choose what must be stored and provide additional information. Teachers can search and browse the
archive flexibly, and unpack an archived learning unit back into the NetPro database for reuse. Students may take advantage of archived NetPro learning units in several ways: learning from previous projects, using exemplary projects as models for their own deliverables, using part of archived projects (i.e. bibliography, data sheets and research data) as a source of reusable information. The re-use tools are based on an XML formatted document database conforming to the emerging standards on educational metadata (standard specification by the Learning Object Metadata (LOM) Working Group of the IEEE Learning Technologies Standardisation Committee).

2 - Tools to support group work processes in network based learning projects.

These tools are used to create and maintain a project site. A project site is a specifically structured Web site for team work, available on the NetPro server. The features available in the project site tools include:

- shared group workspace for managing project tasks and deliverables;
- easy publishing of deliverables into the PDC for sharing with the wider learning community;
- collaborative and distributed authoring and annotation of group documents with locking and version control of documents;
- repository for resources and assets needed in the project;
- interactive project log that can be used for recording decisions made, actions taken or milestones reached;
- interactive meeting memo for documenting project meetings;
- project status tool for providing summary information about the status of project;
- access to the peer coaching tool
- contact info provides a page for information about the team members, information can be updated interactively;
- automatically generated chronology list of all the deliverables and resources uploaded to the project site;
- audio and video communication tools to support virtual teamwork.

3 - Tools to support monitoring and assessment of individual learning in NBPL:

With the learning log tool the students can interactively create and update their learning log. With this tool the student can regularly record and reflect on her/his learning experiences during the learning process.

The peer assessment tool offers a facility for the project teams to assess one another's contribution by awarding grades against a given set of criteria. The supervisor can interactively create a Web-based form to be used in such assessment.

NETWORK BASED PROJECT LEARNING IN PRACTICE

In NetPro, different teams of students work on a common project, forming a community. Here learning within, and between, international project teams is supported, using models and tools as outlined. Learning is based on the development and discussion of typical engineering artefacts, such as specifications, designs and progress reports. Students carry out the majority of the NetPro work independently in small teams, following the project process defined by the teacher. The project is typically structured into phases and related deliverables.

The custom Internet tools are designed to provide services to both teaching staff and learners. For the teachers and tutors, NetPro provides management tools to support the establishment and delivery of network based project learning, such as indexing of projects and deliverables, setting-up of collaborative learning activities, distribution of support and reference material, and efficient tracking of learners’ activities. Sharing, exchange and re-use of established NBPL schemes are also supported by the browsable archiving and re-use system.

For the learners, the tools provide access to project and learning related information resources, and support for project and team management, for distribution and sharing of project deliverables to the learning community, and for collaborative learning activities (such as peer reviewing, discussion forums and peer coaching), peer assessment, and so-on.

The Distributed Learning Environment

The NetPro learning environment (NBLE) is a distributed system where each participating pilot site has its own local learning environment integrated with the collaboration space provided by the project. The collaboration space is a database application with user specific Web interfaces, accessible through a standard Web browser. Users do not need any knowledge of Web authoring or special tools to use the application. The two main user interfaces are the Student view and the Admin view (for course supervisors). There is also a view for NetPro system administrator for maintaining the system but it is not discussed here.

Within the Admin view, teachers and tutors can set up the collaborative project learning environment on the Web, and link it into their course site. This includes defining the teams and the required deliverables, defining the project management tools to be used by the project teams, and specifying the specific learning activities (peer reviewing, discussion forums, peer coaching, individual learning logs, and peer assessment). Learners use the Student view for managing their project and team,
to publish their work for the learning community to share, and to carry out the specific learning activities set up by the course supervisor. Both views are organised into several card-like views.

The core of the NetPro learning environment is the Project Deliverables Centre (PDC). The main view of the PDC is a graphic that shows which items have been delivered, using a coloured-‘smiley’ icon 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 course supervisor has three options for specifying how the project teams will publish their deliverables in a PDC:

- Teams develop and maintain their own project site using the NetPro tools. The project sites are maintained on a NetPro server and linked with the NetPro collaboration space.
- Teams produce their sites with any tools that are available for them and then link the public deliverables into the PDC by providing the URL. In this case the deliverable (files) can be stored on any server that the students can access.
- Teams upload to a NetPro server only the deliverables to be published in the PDC. This is convenient (e.g. 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. 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. Uploading of deliverables will be done using any of the supervisor selectable methods described above.

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 any 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 self, or 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 participated. Supervisor can view the peer assessment results at any time, complete or in progress. 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 this data.

Each project has available one or more open discussion spaces, called Special Interest Groups (SIGs). These act as 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.

**PILOT COURSES**

The goal of the pilot courses is to test and evaluate the network based project learning methodologies, environment, and tools developed in the NetPro project. The pilots’ learning environment consists usually of a problem specification and assessment requirements, which may be supported with related network based learning material and documentation.

Traditional lectures, tutorials and laboratories integrate the NBLE. The students study the provided material and then address the problem as required. Tasks require subject-specific engineering knowledge and project-management skills to be applied. Tasks are defined in the student project, and form the context in which the NetPro team is developing the NBLE.

The pilot courses are implemented in the real study context of students, i.e. they are fully integrated into their curriculum and the students generally earn credit units by carrying them out. 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 for organising the project activities locally in the way that fits its curriculum, whilst local teachers and tutors take care of the teaching related to the project. Joint working is possible if
teams use the same language (English in our case), and if the classes involved study the same topic at the same time of year. Experience has shown that cross-institutional co-operation is difficult to implement: the introduction of NetPro courses could be a powerful stimulus toward a better integration among European institutions.

The project has organised, run, and shared by the international partner institutions three streams of pilot courses:

- Software Engineering
- Media Technology
- Electronic Engineering [5, 6]

**CONCLUSIONS**

A successful network-based learning environment for project work has been developed. It is useful for local work, but is particularly convenient for inter-institutional and international co-operation. It has been used on several pilot projects, and development is continuing. The feedback from students and tutors is generally favourable. Teachers not involved in the project piloting have adopted NetPro for their courses.

The project has also started the preparation for a larger-scale transfer activity by prototyping the concept of "NetPro Learning Communities". The long-term goal is to develop a self-funding organisation for promoting and developing project based learning on an Europe-wide scale.

**REFERENCES**


**FIGURES AND TABLES**

**FIGURE. 1**

International Conference on Engineering Education

### Centre: DIBE-DA03/1B-SV, Electronic System Design 1 (INTLBM) 2003

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