ON-LINE LEARNING MATHEMATICS AND SCIENCES

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Abstract

In this paper an European project on development of Web-based courses in mathematics, physics and chemistry is presented. The project is in the framework of the programme SOCRATES 2005–2007 of the European Community. The collaboration involves seven universities from four countries – France, Spain, Belgium and Bulgaria in an active joint work. Within the project some studies on the potential changes in education following the ICT revolution will be conducted. The main research aspects will be related to: pedagogic effectiveness of the ICT-based learning of mathematics and sciences with activity-based approach and simulations; the change in educational mission from instruction to provision of methods for personal learning; the transition from objective to constructed knowledge.

Rationale of the Project

In this paper an European project on development of Web-based courses in mathematics, physics and chemistry is presented. The need analysis identified the following problems and defined the corresponding needs.

There is a deficiency of Web-based materials in mathematics and sciences because of the existing technical difficulties with the presentation of mathematical symbols. If there exist some Web-based materials in these subject matters, they are in form of texts with expository deductive strategy. If there are some tests, they are multiple choice tests and it is mainly because the users can not use easily the scientific symbols when working on the Web. Interactive ICT based materials, simulations and games would improve the attractiveness of learning and the quality of pedagogical relations in these pretty “dry” subject matters.

eLearning requires changes in pedagogy/didactics and organisation of teaching and learning emphasising: activity-based and independent learning; development of complex cognitive skills; variation in resources and environments for learning; teacher role shifting from instructor to facilitator/coach. And we need to learn more about the role of ICT in

learning processes and in this project a pedagogical experiment during the field trial is planned.
Keeping track of student progress and assessing achievements within new learning paths is complicated and takes a lot of time. How to monitor the learning processes and evaluate student learning outcomes? The ICT can help to improve the evaluation process and we intend to use an intelligent adaptive testing system in our project.
The background of the project is the experience of the partners' institutions: the co-ordination by USTL of the French national project for development of eLearning environments (Université en ligne), the system of auto-evaluation for adult education ForEva developed within a Grundtwig project, the methodology of the experimental research for studying the pedagogical effectiveness of eLearning materials developed within a Minerva project IPSS_EE (Mediano et al., 2004). The rationale is to apply all these experiences and to integrate them in one European initiative for eLearning of basic skills as mathematics and sciences as well as to evaluate the pedagogic effectiveness of the innovation.

Objectives

The project is aimed at implementation and evaluation of innovative approaches for activity-based and independent eLearning in mathematics and sciences. Its specific objectives corresponding to the specific needs are:

- Development of on-line *learning environment and courses in mathematics and sciences* based on demonstrations, simulations and problem-solving and development of tools for *distant group-work* for university engineering education.
- Development of new *methods and tools for alternative assessment* of student performance and achievements and adaptation of the learning environment to the individual learning styles.
- *Training teachers* for student centred coaching, in the development and use of eLearning materials and the on-line services for student support; and students for independent and activity-oriented learning.
- *Setting up comparative analyses* for improving the understanding of learning processes and experiences in using information and communication technologies.

Targets

Target groups, which will benefit directly from the outputs/products and activities of the project, are: first and second year students from universities, teachers, engineering education and training providers. The students following the courses in mathematics and sciences at the Technical universities or Schools as they are called in France are thousands. E.g. at the TUS they are 2500 students per year. If the developed environment, courses and approaches will prove effectiveness

the end users will be thousands. In the project, the pilot test will be performed with 45-60 students in each subject matter, and the field trial – with not less then 150 student from the five partner institutions. In the project directly will be involved the course developers, teachers, environment and course producers, and partly the managers of the higher education institutions.

From the pedagogical research will benefit: instructional designers, producers, users and managers of education institutions; training organisations. We expect that the lessons learnt in the project development and during the experiment would have an impact on the whole technical education society.

Users of the project products and outcomes are the higher education institutions, and might be also: HRD departments in enterprises, public unemployment and social work institutions, which could apply the approaches and organisation used in the project in their practice.

Pedagogical and Didactical Approaches

Within the project, studies on the role of ICT in learning processes will be conducted. The main aspects of the research will be related to: pedagogic effectiveness of the *student centered task-performance oriented learning*; the change in educational mission from instruction to the provision of methods for personal learning; the transition from objective to constructive knowledge (Van Merriënboer, 1999). The effectiveness of the *group-work in mathematics* will be tested also. This approach is used till now only in world Olympiads on mathematics and it is proven effective for highly talented pupils. In this project we will test it with university students.

For the pedagogic effectiveness of the new courses an *experiment* with pilot groups of students is planed. The experiment will be performed during the pilot test and the field trials.

One of the project objectives is to set up *comparative analyses* for improving the understanding of learning processes and experiences in using ICT. The hypothesis is that the *discovery inductive* strategy for an independent learning in the environment of OnLineMath&Science proves pedagogic effectiveness as indicated by performance, attitudes and perceptions of students.

The learning materials and the organisation of the courses we are designing for *a hybrid mode of delivery* with a) Web-based modules with tutoring in asynchronous (by e-mail and file transfer) and synchronous mode (on-line contact with tutors and other learners, computer conferencing for the whole group), and b) some forms of face-to-face learning, e.g. workshops and practical work, group discussions, case studies.

Telematics gives an impetus to more active and constructive learning with more emphasis on inter-personal collaboration, social networking, peer exchange and group activities. This only works if the computer network is combined with a *social network*. The learning contexts and organisational

settings within the learning environment provides opportunities for: 1) small groups executing a specific task as a workshop, assignment, project; 2) discussion groups with peer students; 3) tele-assistance of the tutor during task execution and/or exploration; 4) detailed advice by contacting domain experts etc.

As we already mentioned, the discovery inductive strategy is mainly used, in which the students design their own projects and interpret the results (Tzanova et al., 2004). Students are given the specifications of a device, process or the mathematical problem to be solved and the principles of project development and management will be explained. Learners work in groups of three people, as a minimum, led by a project manager. The focus is on joint responsibility, information sharing and discussion. Students should plan the organisation of the team, decide who will play the role of the manager, and plan the activities to be performed for the project development and the techniques and tools to be used. The team manager should co-ordinate the work and monitor the project development progress.

In order to improve the effectiveness of the science education and consequently to lower the drop-out in the first two years in the engineering education institutions we wish to offer to students personalised training activities, intervening as function of adaptation to their personal competencies and attitudes. These activities are being designed and produced using a methodology and the software system ForEva which has been developed for adult education. This system allows to evaluate the competencies and the knowledge obtained in and outside the institutional educational system, and to provide the most adapted training. It thus allows a true integration of personal data in the definition of personalised learning paths. In this project the system is being re-designed for the new users – university students.

Innovation

The project aims to implement innovations in the:

Content of the learning materials: University degree courses *in mathematics and sciences* will be developed. There is a lack or deficiency of Web-based materials in these subject matters.

Approach: In the “traditional” educational systems usually the expository deductive instructional strategy is used especially for mathematics and sciences: content presentation, examples, sometimes exercises and, rarely task for performance. The broader-systems thinking approach to the learning processes, leads to the design and delivery of activity-based training system and calls for some principal changes in the instructional design of course materials. In this project *discovery inductive* strategy is implemented in an intelligent computer-assisted instruction related most to problem-solving. Tools for *synchronous communication and group work* are being developed – new for mathematics teaching methods (except in the world Olympiads on mathematics).

Assessment: The students' assessment is changed in term of well-performed task, i.e. solution of problems. Goals and objectives transform the measurement of achieved knowledge and skills to the measurement of impact on performance. And the evaluation of this impact will be the required level of performance.
Pedagogical research: Within the project some studies on the potential changes in education following the ICT revolution will be conducted. The main research aspects will be related to: pedagogic effectiveness of the ICT-based learning of mathematics and sciences with activity-based approach and simulations; the change in educational mission from instruction to provision of methods for personal learning; the transition from objective to constructed knowledge.

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References

- Kessels, J.W.M. (2001). Learning in organisations: a corporate curriculum for the knowledge economy, *Futures*, vol. 33, Pergamon Press, pp. 497-506.
- Mediano C. M., Mileva N., Tzanova S., Castro Gil M.-A., Bastiaens T., Stoyanov S., Mathieu N., López Aldea E. (2004). Principales resultados de la utilización de la plataforma educativa IPSS_EE en diferentes universidades europeas, Virtual EDUCA 2004, Barcelona, 16-18 Junio 2004, pp. 84 – 92.
- Tzanova S., Schaeffer C., Morey-Chaisemartin P., Illyefalvi Z., Mouthaan T., Tzanov M., Royer M. (2004). Internet-based performance centred instruction in microelectronics, Information Communication Technologies in Education (ICICTE 2004), 1-3 July 2004, Samos Island, pp. 379-385
- Van Merriënboer, J. J. G. (1999). *Cognition and Multimedia Design for Complex Learning*, Open University of the Netherlands.