Robotics-Enhanced Constructivist Learning: The TERECoP Project

Dimitris Alimisis

Department of Education, School of Pedagogical & Technological Education, Greece

Abstract: This paper presents the European project *"Teacher Education on Robotics-Enhanced Constructivist Pedagogical Methods" (TERECoP)* focusing on the theoretical background, the aims and the methodology of the project and outlining the different stages that are going to be developed during the whole life of the project (2006-2009). Finally some aspects of the project that might be of interest to the education of rural and remote communities and some critical advantages or possibilities offered by the project approach to teachers and students in rural settings are discussed.

1. Introduction

During the last few years popular interest in educational exploitation of robotics has increased (Johnson 2003). Robotics in education is seen as a transdisciplinary, project-based learning activity drawing mostly on Maths, Science and Technology and offering major new benefits in education at all levels (Alimisis et al 2005). Robotics uses 21st century technologies and can foster problem solving skills, communication skills, teamwork skills, independence, imagination and creativity (Karatrantou et al 2005). Taking into consideration that students have a better understanding when they express themselves through invention and creation (Piaget 1974), robotic activities are considered to be a valuable learning tool that can contribute to the enhancement of learning and to the development of student thinking.

The LEGO robot, an outgrowth of Papert's LOGO programming language created in the 1960's, partners technology with the ideas of constructionism (Papert 1980). The LEGO Mindstorms system (http://www.legomindstorms.com) is comprised of building materials (regular blocks, gears, pulleys and axels), sensors (light, touch, sound etc sensors) connecting the robot with the external environment and programming software with an effective graphical interface for writing instructions to the robot. The LEGO Mindstorms system provides a flexible medium for constructionist learning, offering opportunities for design and construction with limited time and small funds (Resnick et al 1996).

Before teachers and educators at all levels hurry up to exploit robotics in education, it seems inevitable that new ways need to be found to integrate it into the school curriculum, given that most schools lack both the resources and the freedom to do this and must work with a national curriculum (Johnson 2003).

The educational meaning of Robotics in school education, the methodology that should be used to introduce Robotics in school and teacher education and the design of robotics-based educational activities within a teacher training curriculum are among the main problems that the TERECoP project ("Teacher Education on Robotics-Enhanced Constructivist Pedagogical Methods") intends to copy with. This paper describes the theoretical context, the aims of the project and the different stages of the TERECoP project. Finally some aspects of the project that could be of interest to the education of rural and remote communities are discussed.

2. Theoretical context

The TERECoP project is inspired from the constructivist theories of Jean Piaget arguing that human learning is not the result of a transmission of knowledge, but an active process of knowledge construction based on experiences gained from the real world and linked to personal, unique pre-knowledge (Piaget 1972). The constructionist educational philosophy of S. Papert (1980) is a natural extension of constructivism and emphasizes the hands-on aspect considering that the construction of new knowledge is more effective when the learners are engaged in constructing products that are personally meaningful to them (Papert 1992). The learners in a constructionist learning environment build something on their own, preferably a tangible object that they can both touch and find meaningful. Students are invited to work on experiments or problem-solving using available resources selectively according to their own interests, search and learning strategies. They are seeking solutions to real world problems, which are based on a technological framework used to engage students' curiosity and initiate motivation.

In this theoretical frame a socio-constructivist view is adopted, where learning is not an individual, but a particularly social and societal activity that means that learning always takes place in a social context (Vygotsky1978). Under such a framework the use of educational technology can contribute to the realisation of meaningful learning based on students' team work with teaching materials. The available e-learning environments can support collaboration between fellow students and educators, who can be at different schools, at home or abroad.

3. Aim and objectives

To engineer a desirable learning effect with or of a technology requires more than just introducing the technology. A crucial factor for the successful introduction of robotics-enhanced constructivist teaching and learning in school education is teacher who is required to play a new role different from that of a traditional transmitter of knowledge to a passive audience. Teachers need to be provided with opportunities, like exposure to a number of critical examples and experience in designing robotic activities and integrating them in their classroom practice in constructivist ways. They need to be convinced by their own personal experience for the potentiality of robotic technology as a learning tool.

Based on this principle, the overall aim of our project is to support teachers' professional development in this field developing a framework for teacher education courses in order to enable teachers to implement the robotics-enhanced constructivist learning in school. Course participants, who will be practicing or in-service teachers, will be provided with opportunities to examine how robotic technologies can be used to promote a constructivist approach to learning under a co-operative and collaborative frame of work and to reflect on their experiences from the implementation of this framework. Striving for a collaborative learning environment is based on the belief that the inherent dynamics of a necessary mutual process are likely to be more conducive to meaningful transformation, carrying so a sense of greater potential for development. This is highly supported by the development of e-learning communities.

More specifically our objectives are:

- To select and organize a repertoire of appropriate robotics-based learning environments that can support robotic activities and produce a set of critical examples for using in a constructivist way with teachers of secondary level in science and technology subjects.
- To test and evaluate the practical implementation of the selected tools both in training courses and in real classrooms situation (by the trainees).
- To develop a methodology of innovative collaborative strategies supporting social constructivist teaching and learning, applied both in the teacher courses and in students' teaching and learning.
- To create a community of practice between educators and teachers for facilitating and sustaining teachers' professional development in using robotic tools to support their students' learning by active exploration and social construction of new knowledge.

The training curriculum design will follow an innovative constructivist perspective with an emphasis on aligning computer and robotic technology with learning objectives and learners' needs for the purpose of constructing meaning in social learning environments. Key issues to be addressed during the project in order to accomplish the pre-mentioned objectives are:

- The integration of technological, cognitive, pedagogical, and social aspects to design and develop learner-centred technology-enhanced learning environments regarding that technology alone cannot affect minds.
- The design of a rich interactive learning environment encouraging constructivist learning where the focus is not on the individual but on the mindful engagement of learners interacting with each other, instructional materials, subject matter, and tools. The implementation of the project

4. The project in action

The project TERECoP started in October 2006 in the frame of the European Programme Socrates/Comenius/Action 2.1 (Training of School Education Staff) and its total duration will be 3 years. 8 institutions from 6 different European countries participate in the project: School of Pedagogical and Technological Education (GR, coordinator), Institut Universitaire de Formation des Maîtres d'Aix-Marseille (FR), Department of Information Engineering – University of Padova (IT), University of Piteşti (RO), IT+Robotics srl (IT), Museo Civico di Rovereto (IT), Charles University Prague, Faculty of Education (CZ), Public University of Navarre (ES).

During the 1st year a methodology for designing robotic technology-enhanced constructivist learning will be developed and teacher education courses will be designed. During the 2nd year a pilot and a final teacher education course will be implemented including testing of trainees' teaching activities in school classes. Finally during the 3rd year the evaluation of the courses and the development of dissemination activities will take place.

The *target groups* of the project include:

- student-teachers expected to be educated in a way that robotic technology-based learning will play an important aspect of their future work as teachers or professional educators
- in-service teachers expected to become aware of the robotic technology-based learning and of different classroom uses and activities for improving their students' learning in science and technology
- teacher educators expected to be informed for providing similar courses in local level and
- educational authorities expected to undertake future action on teacher technology-based education and further training

An *e-community* (http://eclass.gunet.gr/) has already been created to offer for the partners (from the beginning of the project,) and for teacher-students (during the 2nd and 3rd year) a communication platform including:

- a public space available for all the members of the community (educators and student-teachers) to post their messages and to upload their files;
- forum to facilitate the dialogue on selected topics related to the project subject;
- synchronous and asynchronous communication services (announcements, chat and e-mail).

The main function of the e-community is to support (during the 2nd and 3rd year) the development of a learning community engaging the teacher–learners in social learning, supporting meaningful conversations among learners and between educators and learners, promoting new perspectives and helping them to construct knowledge in a collaborative way.

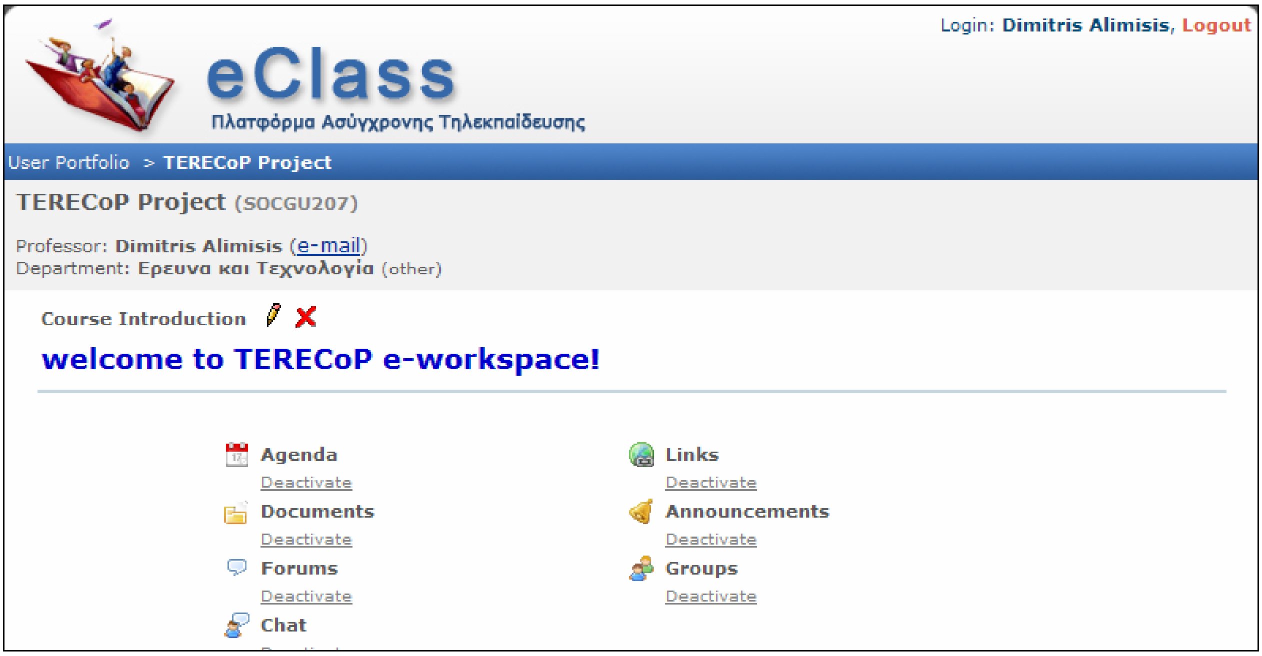

Figure1: *the main page of the TERECoP e-workspace*

A project web site (**http://www.terecop.eu**) presents the whole work done in the frame of the project and connects the project with the broad educational community.

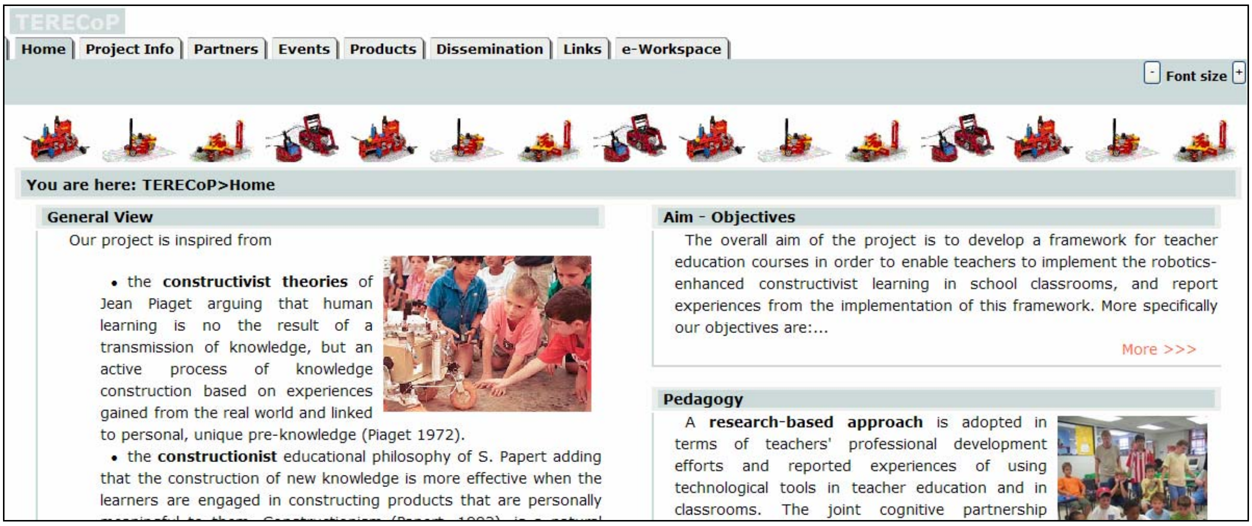

Figure 2: *the homepage of the TERECoP website*

The partners are currently working to develop a methodology for designing robotics-enhanced constructivist learning that could be applied both in teacher training courses and in students' teaching and learning. Our methodology, incorporating results from relevant research literature (http://www.terecop.eu/downloads/synthesis0107.zip including books on subject, educational journals, proceedings of educational conferences, web resources and educational software tools), outlines basic principles, learning objectives and strategies and appropriate technology-based environments. Our methodology describes in details learning activities and some critical examples of robotics-enhanced constructivist learning. The whole design of the teacher education courses, including learning materials and evaluation tools, will be based on this methodology.

At a first experimental stage the pre-mentioned course design will be implemented and evaluated with student-teachers in three different countries by the corresponding partners. From the beginning of the face to face course student–teachers will be invited to participate in an e-community and will have access to e-learning materials. They will elaborate on the development of robotics-based constructivist teaching activities and materials for their students and will be encouraged to create and present joint projects on constructivist teaching activities planned to be implemented with school students, and to argue for their choices. The student-teachers will also be encouraged to implement their projects in real school classes, where it is possible, and to evaluate them in cooperation with their tutors. The projects and the evaluation results will be published and discussed in the e-community where educators and teachers will have the opportunity to share and reflect on their experiences.

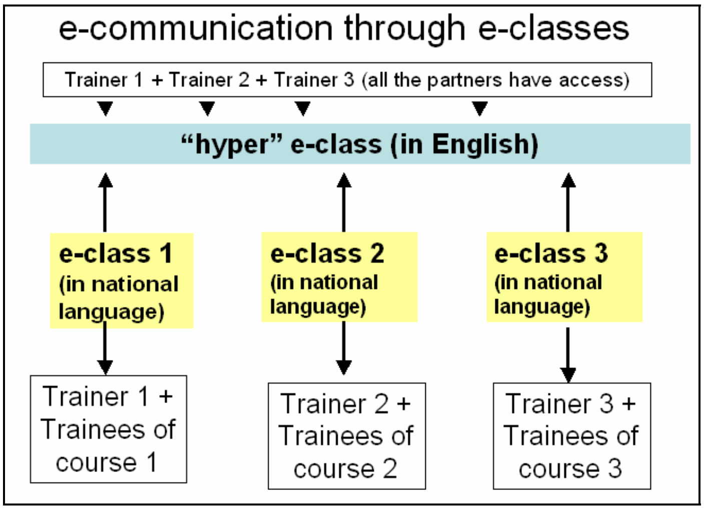

Figure 3: *the structure of e-classes running during the training courses*

An evaluation report on each of the pilot courses based on data collected in the courses and on data collected from the implementation of students' projects in a real school class will be presented to all the partners and will offer feedback for designing a revised curriculum and new learning materials. After that, 3 new teacher training courses will be organized in the other three of the participating countries using the revised curriculum and learning materials. The results and findings obtained from a new evaluation process will allow the project consortium to produce a final curriculum and improved materials.

After the end of the project (September 2009) the final course, as it will have been refined then, will be available through the Comenius Catalogue for in-service training of secondary science and technology teachers from the whole European educational community.

5. Aspects of the project that might be of interest to rural and developing communities

The growing demand for technological innovation to enable empowerment of rural and developing communities requires new and creative educational initiatives. Thus, well designed educational initiatives geared towards appropriate technology for rural and developing communities can have a significant impact on their education and development (**Dias et al 2005).**

A few robotics projects and workshops have been developed with a key focus to enable children in rural communities to participate in robotics education (for instance "Robotics for Technology Education" http://www.itee.uq.edu.au/~peta/_RoboticsForChildren.htm) or to build capacity and expertise in robotics (benefiting mostly subjects like Maths, Science and Technology) and online learning in teachers in rural schools even when the local teachers have little knowledge in this cognitive area ("Robotics Online", http://www.simerr.educ.utas.edu.au/).

Educational change is not simply a matter of access to new technologies. Technology cannot act directly on learning. Other important elements to the educational success for rural communities include an appropriate education philosophy, new curriculum and learning environment, and appropriate teacher education and training programs.

Although the target group of the TERECoP project includes secondary school teachers at European level in general and doesn't focus on rural communities, the proposed robotics-enhanced learning methodology and technology is important for rural communities since it offers some critical advantages or possibilities to teachers and students in rural settings.

In our project's constructionist view, robotic technologies are not seen just as tools, but rather as potential carriers of new ways of thinking about teaching, learning and education. Projects inspired from constructionist spirit take into account the importance of local knowledge and culture, as well as people's interests and different learning styles. They therefore have the potential to lead to appropriate actions in rural communities relevant to their needs, problems and interests (for example: better transportation, water sanitation, preservation of scare resources, etc.) and to their community assets (agriculture, livestock, recreation, etc) (Urrea 2007).

Our project's constructionist approach encourages learners to participate in decision making, implementation, and evaluation of the project. Our constructionist philosophy tries to empower the learners with active involvement, designing, and making decisions about their own learning. So, students and teachers are expected to become responsible for their own learning, to work at their own pace and to be provided the tools to reflect upon their communities. They therefore are invited to see themselves as active participants and creators of their own educational and learning realities. This is in turn expected to give them a sense of ownership and responsibility not only for their learning but also for their lives and communities. In addition, it is expected to give them skills that they can use well beyond the timetable of the educational projects. For example, the collaboration between members of the school and the community can make a big impact on the ways in which people in the community see themselves and are seen by the developing world (Urrea 2007).

Acknowledgements

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