Exemplary Projects

Designing Robotics-Enhanced Constructivist Training for Science and Technology Teachers: the TERECoP Project

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Abstract: Over the last decade, at an international level, quite a few efforts have been made to include robotics in the secondary school education, mainly in science and technology subjects. However, even though the teacher's role in an effective and productive incorporation of that kind of technology in the educational process is of particular importance, very few teacher further education attempts have been recorded. Focused on that direction is the European project "Teacher Education on Robotics-Enhanced Constructivist Pedagogical Methods" (TERECoP), developed within the framework of the European program COMENIUS with the participation of 8 educational institutions from 6 European countries. This paper presents the project in question with special reference to the curriculum of a teacher training course, which is aimed at the use of robotics in education and which has been designed and already implemented on a trial basis within the framework of the aforementioned project, following the constructivism, constructionism and project-based learning principles.

Introduction

Over the last few years, interest in educational utilization of robotics has increased (Johnson 2003). Robotics in education is seen as an interdisciplinary, project-based learning activity drawing mostly on Maths, Science and Technology and offering major new benefits to education at all levels. The use of robotics in education is aimed at configuring a learning environment that will actively involve learners in the solution of authentic problems, will enhance learners' research attitudes, will allow learners to make assumptions, carry out experiments and develop their abstracting skills, enabling them to control the behavior of a tangible model by means of a virtual environment (Resnick et al 1996).

The role of teachers in the effective introduction and use of robotics in the educational process is particularly important. Nevertheless, whereas quite a few studies on the educational potential of robotics have been recorded (Alimisis et al. 2005, Dias et al. 2005, Johnson 2003, Bers & Urrea 2000, Portsmore et al. 2004, Erwin et al. 2000) very few of them refer to teacher further training on issues concerning the design and utilization of programmable robotic constructions in teaching practice (Bers et al. 2002, Portsmore et al. 2003, Knight & Cyr 2004).

Activated in the field of educational robotics is the European project "Teacher Education on Robotics-Enhanced Constructivist Pedagogical Methods - TERECoP" with the participation of 8 European educational institutions from 6 European countries, its goals being:

- the development of a design and implementation framework for activities related to programmable robotic constructions and based on modern teaching and learning theories;
- the development of activities advisable for secondary school education;
- the training of prospective and in-service teachers on certain technologies of robotics and the educational benefit from the implementation of such technologies at a European level.

This paper gives a brief description of the theoretical context and the goals of the project in question, of the activities already developed or planned to be developed during the project duration (October 2006- September 2009) and of an initial pilot teacher training curriculum. That curriculum concerns the design and implementation of robotics activities in secondary school education, based on constructivism and constructionism principles and the approach of project-based learning in the organization of learners' practice in classroom.

Theoretical context

The successful introduction of an educational innovation and the educational change is not just a matter of access to new technologies. Technology alone cannot affect students' minds and cannot act directly on learning. An

appropriate educational philosophy, a new curriculum and learning environment and appropriate teacher education and training programmes are some of the important elements leading any educational innovation to success.

In view of the above, before teachers and educators at all levels rush to exploit robotics in education, it seems inevitable that appropriate teaching methods need to be found and incorporated in the school curricula, given that most schools and teachers lack not only experience and resources, but, also, in most cases, they have to work under a national curriculum that does not favour the inclusion of any of such innovative activities in the school programme.

In the TERECoP project, a constructionist view (Papert 1980) is adopted, whereby robotic technologies are not seen as mere tools, but rather as potential vehicles of new ways of thinking about teaching, learning and education at large. Our project is inspired by the constructionist spirit, taking into account the importance of students' knowledge and culture, as well as their interests and varied learning styles. Our constructionist approach tries to help learners by means of active involvement, as it encourages them to participate in the decision making, implementation, and evaluation procedures of the project. Accordingly, learners are invited to see themselves as active participants in and creators of their own educational and learning realities. In addition, learners are expected to acquire skills that they can use well beyond the timetable of this educational project. For example, the collaboration between trainees and trainers within the framework of the project may cause a great impact on the ways teachers see themselves and their role in the school communities to which they belong.

Learners, in a constructionist learning environment, build something on their own, preferably a tangible object that they can both touch and find meaningful. Learners are invited to work on experiments or problem-solving with selective use of available resources, according to their own interests, search and learning strategies. They seek solutions to real world problems, based on a technological framework meant to engage students' curiosity and initiate motivation (Papert 1992).

The LEGO Mindstorms NXT system (http://www.legomindstorms.com) attempts to partner technology with the ideas of constructionism. It offers building materials (regular blocks, gears, pulleys, axels etc.), sensors (light, touch, sound etc.) connecting a robot with the external environment and programming software with a simple graphical interface intended for the creation of robot behaviours.

Aim and objectives

On the premise that the crucial factor for successful introduction of robotics-enhanced constructivist teaching and learning in school education is the teacher who is convinced by his/her own personal experience about the potential of robotic technology as a learning tool, the overall aim of our project is to support teacher professional development in this field by developing a framework for teacher education courses with a view to enabling teachers to implement the robotics-enhanced constructivist learning in classroom settings. Course participants will be provided with opportunities of examining how robotic technologies can be used to promote a constructivist approach to learning within a co-operative and collaborative framework.

More specifically, our objectives include the designing of appropriate robotics-based learning activities, the production of a set of critical examples for their use in a constructivist way by teachers at a secondary school level in science and technology subjects, the testing and evaluation of those activities by trainees, in training courses, as well as in real classroom settings, and, lastly, the development of a community of practice between educators and teachers expected to facilitate and sustain teachers' professional development in the use of robotic tools in their classrooms. The accomplishment of the aforementioned objectives highly depends on the successful integration of technological, cognitive, pedagogical and social aspects, which will allow the design and development of learner-centred technology-enhanced learning environments, i.e. the basis of constructivist learning.

The target groups of the project include prospective and in-service teachers expected to become aware of the robotic technology-based learning and its different classroom uses and of classroom activities meant to improve students' learning in science and technology, so that the robotic technology-based learning may play an important role in their future work as teachers or professional educators.

The workplan

The project TERECoP started in October 2006 within the framework 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 was developed for designing robotic technology-enhanced constructivist learning for science and technology secondary school classes and training courses were designed (Alimisis et al. 2007). At an initial experimental level, developed during the 2nd year, the aforementioned course design was implemented and evaluated in 6 teacher training courses (October 2007 – May 2008) carried out in each of the 6 participating countries by the respective partners. An evaluation on each of the pilot courses followed expected to provide valuable feedback on designing a revised curriculum and improved learning materials.

Finally, during the 3rd year (2008-09), the evaluation of the courses based mainly on data collected during their implementation will take place. The results and findings expected to be obtained from the evaluation of the courses will allow the project consortium to produce a final curriculum and training materials that will be published in printed and digital form. The whole experience, coming from the project activities, will be presented to the educational and research community across Europe for discussion through conferences and journals. An international workshop is also planned to be organised by the project partnership for that purpose (November 2008).

An e-community (http://eclass.gunet.gr/) has already been created to offer to the partners (from the beginning of the project) and to trainees (during the courses) a communication platform, including a public space available to all the members of the project community (trainers and trainees) allowing them to post their messages and upload their files, i.e. a forum promoting the dialogue on selected topics related to the project subject. The main function of the e-class is to support the development of a learning community engaging the teacher–learners in social learning, to support meaningful conversations among learners and between educators and learners, to promote new perspectives and to help them to construct knowledge in a collaborative way.

The pilot training course curriculum

Based on the aforementioned methodology (Alimisis et al. 2007), a pilot teacher training course was designed and training materials were prepared. The partners working in this project strongly believe in the educators' axiom: *teachers teach as they are taught, not as they are told to teach*. It is not enough for trainers to describe new ways of teaching and expect teachers to translate from talk to action; it is more effective to engage teachers in activities leading to new actions in classrooms. Thus, pursuing the constructivist professional development of teachers, we have designed learning activities that teachers could include in their own classes and a course curriculum following the kind of constructivist spirit that we would like our trainees to cultivate in their school classes.

The course design follows the model of blended learning combining face to face classes (32 hours) with e-learning activities. From the beginning of the face to face course, trainees are invited to participate in an e-learning community (http://eclass.gunet.gr). Through this e-class, trainees have access to e-learning materials, can collaborate on the development of robotics-based constructivist teaching activities and materials for their pupils, can create and present joint projects on constructivist teaching activities planned to be implemented with school learners and can argue in support of their choices. The modules of the pilot course curriculum are briefly presented in the following lines.

Module 1: Introductions (or "breaking the ice") (1h)

Objectives: To help trainees relax and ease; to learn each other's names and personal/professional particulars; to identify individual learning needs and goals, expectations and possible learning difficulties.

Training activities: The trainer and each trainee introduce themselves or (alternatively) the trainees, in groups of two, interview each other for few minutes and each one of them introduces the other one in short to the whole class. The trainees post a message in the forum introducing him/herself.

Module 2: Agreeing on a "didactic contract"; assigning readings on constructivism and constructionism to the trainees (1h)

Objectives: To ensure a consensus between trainer and trainees on the training objectives, contents and methods; to generate interest in the topic of the training; to make arrangements necessary for the smooth running of the course;

to invite the trainees to read and analyse selected papers focusing on the subject of the course, that is constructivism, constructionism, project-based learning and robotics.

Training activities: The trainer presents the overall aim, the specific objectives of the course, the training methodology and the expected training results.. The trainees are invited to express their own expectations, opinions, suggestions and ideas. The session finishes with an agreement between trainer and trainees on the issues mentioned above (and on everything else that might emerge in the training class) leading to the formulation of a "didactic contract". The "didactic contract" is uploaded by the trainer in the *Documents* area of the e-class. A short presentation/introduction /guide-to-read of the selected papers follows and the selected papers become available for trainees through e-class.

Module 3: robotics as learning object (or getting started with robotics) (12h)
Why robotics in education?

Objectives: To motivate trainees to use robotics in education; to conceive robotics as an innovative technology that can create a rich interactive environment encouraging constructivist learning and supporting the realisation of meaningful, authentic, collaborative learning tasks, providing opportunities for design and construction, and for the development of student thinking; to understand why Lego Mindstorms NXT technology can be used as a tool for the accomplishment of the above learning tasks; to provide an initial introduction into the Lego Mindstorms NXT Educational kit and software.

Training activities: Trainees, based on one of the uploaded papers available through e-class, work in groups of 4-5 on a relevant challenging question (for example *Why robotics in education?*). They present and discuss their ideas and the trainer makes a synthesis. The trainees publish and exchange opinions on the same topic in the forum of their e-class. Then the trainer presents the Lego Mindstorms NXT Educational kit and software. The trainees explore the hardware components, browse the Lego Mindstorms NXT brick menus and familiarize themselves with the basic functions of the NXT brick through lab activities working in groups.

A first approach to Lego Mindstorms NXT)

Objectives: To enable trainees to assemble robots in different configurations for solving/studying a given problem/scenario; to create simple programs in order to control robots, to read the sensors and to activate the motors using basic programming blocks within the Lego Mindstorms NXT software; to evaluate their constructions according to criteria set by themselves; to check if the robot has the desired behavior and, if not, to be able to repeat the process until a reasonable solution can be reached.

Training activities: the trainees work doing practical lab activities in groups (build their own robots and make their own programs) followed by group discussions and presentations to the whole class. The LEGO Digital Designer software (http://ldd.lego.com), manuals and worksheets providing scenarios and help for the he construction of robots are available for the trainees in the class (all the materials are also available in the e-class).

Module 4: Constructivism, constructionism and project-based learning (4h)

Brainstorming
Objectives: To activate any prior knowledge of the trainees on the subject; to bring the experience of all trainees into play during the session; to utilize the experience and creativity of all trainees; to introduce trainees into the subject of the module through their own experience.

Training activities: The trainer sets the question (for example *How the use of robotics technology in school class could change the traditional teacher-centred model of knowledge transmission?)*, encourages an enthusiastic, uncritical attitude among trainees, tries to get everyone to contribute and develop ideas, and notes down the ideas that come out of the session. Finally s/he makes a synthesis summarizing trainees' ideas as they have emerged from brainstorming. The trainees are encouraged to find, share and present on qualitative resources / papers (one or two) about the role of robotics technology in education through the forum of their e-class and the dropbox utility.

Constructivism and constructionism in education

Objectives: To offer to trainees a constructivist and constructionist view of learning; trainees to conceive how the constructivist and constructionist principles may be applied in education focusing on the creation of a student-centered learning environment and on the artefact creation, as part of the learning outcome based on authentic and

real life experiences.

Training activities: Trainees work in groups of 4-5 on a specific question based on one of the uploaded papers (Ackermann 2001) available for trainees in e-class.; trainees present and discuss their ideas. The trainer makes a synthesis. The trainees publish and exchange opinions on the same topic in the forum of their e-class

Project-based learning

Objectives: To recognise the educational advantages of project-based learning as a model for classroom activities that shifts away from the classroom practices of short, isolated, teacher-centered lessons and, instead, emphasizes on learning activities that are long-term, interdisciplinary, student-centered, and integrated in real world issues and practices.

Training activities: Trainees work in groups of 4-5 on a specific question based on one of the uploaded papers (Carbonaro et al. 2004) available for trainees in e-class; present and discuss their ideas, the trainer makes a synthesis. The trainees publish and exchange opinions on the same topic in the forum of their e-class; the trainees are encouraged to evaluate the particular learning experience described in the paper (based on specific criteria) through the forum of e-class.

Module 5: Robotics as learning tool (or designing projects with robotics) (10h)
Features of a robotic project; Methodology on how to organize a project

Objectives: To enable the trainees to specify important features of a robotic project according to constructivist and constructionist approach; to describe a framework for the design of a robotic project.

Training methods: Trainees working in small groups make a list of important features of a robotic project and present it to the class. Trainer and trainees discuss the proposed lists and create jointly a complete list. The final list is published in the documents folder of their e-class. Using the outcome of the previous discussion, trainees and trainer construct a general framework for robotic projects.

An exemplary robotic project

Objectives: To enable the trainees to recognise appropriate strategies and tools for each stage of the project; to identify appropriate activities for students at each stage; to describe the teacher role at each stage.

Training methods: the trainer presents a robotics-enhanced project developed in five stages including the learner's engagement in the problem, exploration of the available materials and resources, investigation of possible solutions, sharing of solutions between the groups resulting in a creative synthesis of a final product or solution and finally the evaluation. The trainees working in groups realize the proposed project and analyse each stage according to the teaching strategies, student and teacher activities. They organise their ideas in a tabular form. Worksheets and support materials are available through e-class. The work done by each group is published in their folder in e-class.

Apply the model to a new robotic project

Objectives: To enable the trainees to apply the model of the project they have studied and to design their own projects.

Training methods: Trainees, in groups of 4-5, are asked to use the tables they have completed during the previous session in order to develop a new project of their own preference. Trainees use forum, chat and group components of the e-class to exchange ideas and drafts.

Presentations - evaluations

Objectives: Trainees to get feedback from peers and trainer.

Training activities: Each group publish their project in the e-class and present it to the whole class. Trainees and trainers comment and evaluate them according to agreed criteria.

Module 6: Course evaluation (4h)

Objectives: To assess the course design, content, pedagogical approaches and realisation.

Activities: Interviews with trainees using structured questionnaire centred on objectives, activities and contents of the pilot course. Analysis of the diaries written by the trainees after each training session. The trainers write up an evaluation report exploiting data from the interviews and the diaries, the evaluation of the trainees' projects made in the previous session, the feedback provided by the trainees through the e-class during the course. The evaluation results and reports are published and discussed in the public space of the e-class.

From the training course to the school class

After the course the trainees are encouraged to implement their projects in real school classes and to evaluate them in cooperation with their trainer. Their projects and the evaluation results will be published and discussed in the e-class, where trainers and trainees will have the opportunity to share and reflect on their experiences from the implementations in school classes.

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