Introducing robotics to teachers and schools: experiences from the TERECoP project

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Abstract

This joint paper is based on cooperative work done by the TERECoP project partnership during the 3 years of the project (2006-09) and presents a constructivist methodology for teacher training in robotic technology and its implementation within the framework of teacher training courses. The courses gave teachers the chance to pass from their initial role of a trainee in robotics to that of a teacher planning activities in robotics for their pupils. Some indicative examples from teacher training courses and activities in school classes are presented and commented. Finally, conclusions and recommendations based on our 3-years experiences from the TERECoP project are attempted. The TERECoP partnership through this paper aspires to contribute to the further development of the dialogue within the broader European and international community of educational robotics under the light of constructionism theory.

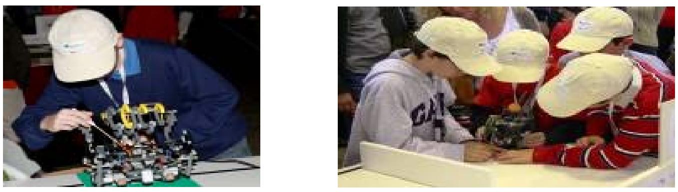

Figure. Greek pupils in action with Lego Mindstorms NXT robotics kit

Keywords

Educational Robotics; Teacher Training; Constructionist Learning

Introduction

It was 3 years ago in EUROLOGO 2007 conference, just some months after having started the TERECoP project, when we presented our project aims, aspirations and expectations emphasizing then that "TERECoP project's aim and ambition is to contribute a constructivist model of teacher training in these new (robotic) technologies… TERECoP project is expected to be a beneficial one for teachers both at national and European level enabling them to introduce robotics in their classrooms in a constructivist framework…" (Alimisis et al., 2007).

Now, a few months after the end of the project, this joint paper, based on the cooperative and shared work done by the TERECoP partnership during the 3 years of the project, comes to summarize our experiences from the implementation of pilot teacher training courses and interventions in school classes and to offer some of our conclusions drawn from the evaluation of those activities.

Theoretical background and methodology of the TERECoP Project

Research in the field of educational robotics has for years placed emphasis on the interplay between the invention of new technologies and the development of innovative ways of learning: new pedagogical ideas can lead to new technologies, and vice-versa (Martin et al 2000). Since the late 1960's, research has been developed for robotic construction kits for children focusing on the invention of construction kits and programming tools that children will find easy to understand and control, thus becoming active participants in their learning and creators of their own technological artefacts instead of being just users of devices that others have made for them (Martin et al., 2000).

Educational robotics has been introduced as a powerful, flexible teaching/learning tool stimulating learners to control the behavior of tangible models using specific programming languages (graphical or textual) and involving them actively in authentic problem-solving activities. This is the field where the European project "*Teacher Education on Robotics-Enhanced Constructivist Pedagogical Methods - TERECoP*" was activated during the years 2006-2009 with the participation of 8 European educational institutions from 6 European countries (www.terecop.eu) (Alimisis et al., 2007; Alimisis, 2008; Papanikolaou et al., 2008; Arlegui et al., 2008; Fava et al., 2009).

Over the last few years, several educational projects and initiatives have been developed in the field involving universities, schools or other educational and research institutions. A pluralism of thematic areas, educational objectives, learning approaches, topics and diverse audiences has been involved in past and current applications of robotics in the broader school settings. The TERECoP Project has aimed at the development of a design and implementation framework for activities advisable mainly for secondary school education related to programmable robotic constructions and based on learning methodologies inspired from constructivism (Piaget, 1974) and constructionism (Papert, 1992) theory. According to our view robotics projects and activities in school settings might be classified in two separate categories:

- Robotics as learning object: This first category includes educational activities where robotics is being studied as a subject on its own. It includes educational activities aimed at configuring a learning environment that will actively involve learners in the solution of authentic problems focusing on Robotics-related subjects, such as robot construction, robot programming and artificial intelligence.
- Robotics as learning tool: In the frame of this second category, robotics is proposed as a tool for teaching and learning other school subjects at different school levels. Robotics as learning tool is usually seen as an interdisciplinary, project-based learning activity drawing

mostly on Science, Maths, Informatics and Technology and offering major new benefits to education in general at all levels.

In the TERECoP project, a constructivist view for learning was 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. Learners, in a constructivist learning environment are invited to work on experiments and authentic problem-solving with selective use of available resources according to their own interests, research and learning strategies. They seek solutions to real world problems, based on a technological framework meant to engage students' curiosity and initiate motivation. The LEGO Mindstorms NXT system (http://www.legomindstorms.com) was selected among others since we found it appropriate to partner technology with the ideas of constructivism and costructionism. It offers building materials, sensors connecting a robot with the external environment and programming software with a simple graphical interface intended for the creation of robot behaviours. In addition to that, it is a mostly open platform allowing the development of a large variety of formal and informal robotics-oriented activities, as the huge number of initiatives and examples shown on the Web confirms (www.legoeducation.com).

Believing that the role of teacher is crucial for the successful introduction of technological and pedagogical innovations in classrooms, the TERECoP Project focused on the training of prospective and in-service teachers in the use of robotics technologies through courses implemented in each of the six participating countries, the evaluation of the training courses and the dissemination of the educational results at European level. As part of the TERECoP activities, we developed pilot training courses for in-service and student-teachers. The aim of the courses was to enable trainees to understand the pedagogical perspectives of educational robotics and to develop robotic activities within a constructivist and constructionist teaching and learning approach.

The idea of “learning by design” is central in our pedagogy supported by a project-based learning approach. The learning tasks of the course are organized as small or large scale robotics projects encouraging trainees to design and develop their own products. As Rusk et al (2008) point out, the way robotics is currently introduced in educational settings is unnecessarily narrow and suggest that designing activities, focused on *themes* and not just on *challenges,* helps to engage wide and diverse audiences in robotics. In accordance with this idea, the projects proposed in our methodology focus mostly on themes broad enough to give everyone freedom to work on a project according to their interests and are developed around open-ended problems engaging participants not only in “problem solving” but also in “problem finding” (Rusk et al., 2008).

The active involvement of the trainees in all the parts of the course was the second important aspect. A teacher training course can contribute to the professional development of teachers, by forming relations between teachers’ existing experiences and the proposed new educational technologies. So, from the beginning of the course, trainees were encouraged to express themselves and to participate in all activities of the course through discussions in small groups, presentations in plenary sessions and publications on their e-class. In this way, current ideas, beliefs and attitudes of the participants were made explicit and evaluated within the constructivist approach.

Throughout the course, trainees were working on their learning tasks independently. The role of the trainer was to facilitate the learning process by creating an interesting and stimulating learning environment: giving feedback at regular intervals, raising interesting questions, guiding the research concerned and synthesizing ideas. Trainees, on the other hand, were responsible for their work; they could follow their own path in their exploration and could develop their own ideas. They were supported in their work by useful resources, such as worksheets, representative examples and user guides. We were also aware that teachers need and appreciate support after the training phase in form of fora, Q&A sessions with the trainers and exchange of experiences during their implementations in classroom. In the pilot activities we also provided this support, when possible, with positive results.

Finally, the constructivist learning environment was based on cooperation. Social interaction within small groups generates a fruitful learning environment, where ideas are expressed, discussed and developed. So, the most of the learning tasks were performed by the trainees working in small groups.

Training teachers in educational robotics

Some indicative examples from the TERECoP training activities are presented shortly in the following sub-chapters just to shed light on the above mentioned theoretical ideas and methodology.

The training course held in Athens, Greece

The TERECoP group in Greece involved researchers and teachers from secondary and tertiary education. The central concept of the training course implemented in Greece was to build constructivist professional development sessions based on learning activities that teachers should be able to use in their own classrooms (Papanikolaou et al., 2008). To this end we used the methodology for designing robotics-enhanced activities for secondary school students which we had developed in previous stages of the TERECoP project (Frangou et al., 2008).

The course was held at the premises of the School of Pedagogical and Technological Education (ASPETE) in Athens, and was organized in 5 face to face meetings of six teaching periods each (5x6=30 teaching periods in total) during 3 Fridays/Saturdays afternoons. In this course 4 trainers and 23 trainees participated: 15 teachers in service (4 from primary education and 11 from secondary education) and 8 candidate teachers. During the course, trainees worked in a constructionist learning environment since they were actively engaged in hands-on activities, working in teams with peers. To enhance the sense of community and promote collaboration through the course an e-class was also maintained.

During the training course, trainees undertook multiple roles. They initially worked as students to familiarize themselves with materials and the programming environment, then they worked as teachers to reflect on the methodology for designing robotics-enhanced activities used in TERECoP and on the pedagogical implications of working with programmable robotic constructions in the classroom, and finally as designers constructing their own project. Finally six projects were developed by the teachers and evaluated by both trainers and trainees.

The evaluation of the course was based on the trainees' products through the course and mainly on the projects they developed, on diaries kept by the trainees during the course sessions, on questionnaires filled in by the trainees and on a semi-structured interview at the end of the course. Based on the evaluation results, we identified that the trainees:

- recognised their active participation in all the sessions of the course and their creative involvement even in the theoretical parts introducing constructivist and constructionist principles and the methodology for designing robotics-enhanced projects;
- very much liked the activity-orientation of the educational content;
- acknowledged the central role of the e-workspace during the face-to-face meetings and beyond them in enhancing social interaction and promoting a positive sense of community;
- acknowledged the potential of educational robotics as a teaching tool but also as a subject in different disciplines such as technology, informatics, and engineering;
- highly appreciated the opportunity to create their own projects.

Training experiences from Italy and Spain

In this section we present some relevant results from 3 actions (pilot training courses) that have been carried out in Italy and in Spain. These activities had a "second demonstrative part", respectively the Discovery Film 2008 Exhibition in Rovereto (Italy) and the First Lego League (FLL) tournament in Pamplona (Spain). The first pilot course was organized in November/December 2007 in the Town Museum of Rovereto (TMR, http://www.museocivico.rovereto.tn.it) which is one of the Italian partners of the TERECoP project and an active and sound divulgation-center in Northern Italy. The course was attended by 15 teachers coming from schools of Trentino and Veneto. The second course was held in April/May 2008 in Pamplona (Spain), where several institutions collaborated to organise it: the Public University of Navarra, the Supporting Center for Teachers of Navarra and CEIN (a public company interested in promoting creativity and innovation among young students). This was a fine example of synergy among the school education system, the local university and an external actor. In both cases, the TERECoP partners from Univ. of Padova (Italy), Public Univ. of Navarra (Spain) and Town Museum of Rovereto acted as trainers.

A third teacher training activity was organized beyond the TERECoP framework but it followed mostly the same curriculum. It was held in October/November 2008 in Bolzano (Italy), hosted by a private senior secondary school that has already integrated robotics experiences within their school subjects (http://www.rainerum.it). It involved about 15 teachers (almost all in-service) from different levels and subjects of specialization. The TERECOP partners from Univ. of Padova and TMR acted as trainers and the local education office loaned some robotic kits to the trainees to stimulate their personal experiences and to enable them to design short school projects during the course period and after that as well. In the meantime additional support was provided by tutors through a web-based specific forum on Moodle platform.

An open activity was organised following the training period, where secondary level students with their teachers (some of them were trainees or tutors in the above mentioned courses) showed their robotics projects and how they were using robotics at their school. In May 2008 the Discovery Film Exhibition in Rovereto hosted an open day for Educational Robotics with stands of several school institutions, exhibitions, meetings, presentations and film showings, all about robotics. In November 2008 the Spanish TERECoP partners co-organised the FLL (http://www.firstlegoleague.org/) tournament in Pamplona as part of the Spanish national qualifications for the international FLL, an international competition for primary and junior secondary student teams supported by an experienced teacher. 15 teams from Navarra and 1 from Zaragoza participated in the first organisation of the event in Navarra. Every team had to design strategies and to build and program Lego robots to achieve pre-defined goals in order to get positive marks during the contest. Every year the contest focuses on a different real-world topic related to science. There was also a scientific project related to the topic of the year that the participating students were requested to develop and present.

Some details about the organization of the courses and their evaluation have already been reported (Arlegui et al., 2008; Arlegui and Pina, 2009). Some improvements and adaptations suggested by the previous experience coming from the course held in Rovereto were implemented in the course held in Navarra. The remarks made by the first group of teacher trainees, like suggestions to allocate longer time for the laboratory activities and to shorten the lectures about constructionism, were followed to improve the course. In the second implementation of the course a video conference system was used allowing partners from Italy to act as distance trainers.

The courses were aimed to achieve two main objectives:

- to assure scientific competences necessary for students to face the nowadays world challenges;

- to design activities and curricula able to adapt disciplinary structures to the learning dynamics.

During the design of the courses, we took particular care to:

- adequately combine inter-disciplinary groups of trainees,
- stress the importance of linguistic aspects during the teaching process (a natural language for group discussions versus the NXT-G formal language for programming);
- identify the trainees' and trainers' tasks during the training process;
- establish a progressive constructivist path for the training course within a Project-based Learning (PBL) approach.

We emphasised that the constructivist approach itself requires experimentations with open problems and that the project is an integrated sequence of problems (in a single purpose and context). So in our courses the constructivist path was achieved combining the following aspects:

- using a PBL methodology and the relevant tools developed during the TERECoP project;
- support of the capacity of abstraction for trainees: for example, some of the intermediate problems were leading to the construction of sub-commands corresponding to *MyBlocks* in NXT-G language.
- sessions organized in such a way that every group "had to construct something concrete" that might be an appropriate robot and/or a successful NXT-G program and to make a good demonstration of how they had worked offering ideas for suitable and affordable (for the other trainees and for their students) problems.

Therefore the work was oriented to build 'intelligent' machines to be controlled following all the steps of the construction, from the design to the realization, using a trial and error methodology, but with clear objectives. Moreover educational paths were designed to introduce robots in teaching scientific subjects, making the trainees confident with the constructivist learning following the aims of the TERECoP project. These aims could be summarized in the 'slogan': *"from robots as **learning objects** to robots as **learning tools**"*.

Training Experiences from Romania

In this section we present some results from the evaluation of the pilot training course that was provided for 15 trainees at the University of Pitesti, Romania. The group of trainees included 7 teachers in service and 8 students already enrolled in a pedagogical module (7 female, 8 male). The evaluation was carried out based on two structured questionnaires filled in by trainees at the end of the course (Part 1: Course design, content and pedagogical approaches and Part 2: Course delivery).

The analyses of trainees' answers showed that all of them considered that the educational module had enhanced the possibility of *acquiring new skills* to create models or to use simulations of science processes and also to use properly sensors and programming interfaces. The vast majority of the trainees considered that the course had enhanced their abilities for applying ICT tools in problem solving (80%), offered performing and accumulation of experiences (86%), methodological skills and realization of reasoning strategies (66%). All the trainees appreciated the applicability of the module in current science teaching as useful. Only few of them declared some difficulties that were related to programming and software development tools and (in one case) to putting together the mechanical parts of the robotic construction. The percent scorings in the second questionnaire highlighted the course was well delivered and well received by the trainees. The issues granted with high scores by the trainees at the end of the pilot course were trainer's enthusiasm (80%) and trainer's relationship with the group of trainees (86%). The support and the organization of the course were also appreciated as excellent (73%).

Generally, positive answers or high ranks were obtained from both questionnaires. The provided course revealed a high interest especially for in-service teachers that found in this a good reason to improve significantly their current pedagogical approaches, although some difficulties were observed to rethink the current topics in the actual curricula using robotics and particularly Lego Mindstorms kit from the constructivist point of view. By the student-teachers this course was perceived as a challenge and was appreciated as a good reason to reflect on the constructivism as a pedagogical strategy. Finally the training course seems that had a really quantitative and qualitative impact on trainees.

Introducing robotics in school classes

After the end of the training courses, our teachers-trainees were encouraged to implement similar robotics activities in their school classes following the proposed methodology. Although robotics is not included in the official curriculum of schools in our countries, which means that teachers should devise and undertake initiatives for introducing robotics in classes and to overcome obstacles related to the official curriculum, many of our trainees tried enthusiastically and succeeded in organising robotics activities in their classes either integrating them in the curriculum or working in after school hours. These implementations offered an evidence for a broader impact that our training courses had on the teachers and finally on their students. Some indicative examples from those implementations in school classes by our trainees are presented shortly below.

Case 1: Integration of Robotics in the curriculum

The following brief quotation from a report written by one of the trainees (teacher Gianfranco Festi, class of 5th year of the Industrial Technical Institute “G.Marconi” of Rovereto, Italy), who participated in the TERECoP course held in Rovereto (October-December 2008), shows a possible way to combine effectively robotics activities within the normal curriculum with public events beyond school.

“This was the third edition of our robotics-oriented project. Even if, the involved teachers are not always the same from year to year, the results were very encouraging and the collaboration with the Town Museum of Rovereto (TERECoP partner) allowed us to realize significant experiences. This year we can use this collaboration to open an innovative educational path. We will participate in several robotics events and exhibitions. The participation in public events is aimed to encourage our students to acquire interdisciplinary skills involving not only the technical subjects but also the humanities. In fact the students, working in small groups are requested to explain in details to visitors what they are showing using the most appropriate media. This turns to be a good experience also for teachers.
Starting form this year, the robotic subject is introduced in the normal curriculum of the technological secondary school. This has several objectives: introduction to programming; Introduction to technology; Introduction to robotics; development of software/hardware solutions in an interdisciplinary framework. Some laboratory hours will be reserved to prepare all the materials to be shown during the public events and namely the next "Discovery on film" exhibition in Rovereto. The necessary equipment, in addition to robots, will be primarily the one for the stand construction, such as posters, laptop and projector to display the multimedia materials. The activity of robotics will take place during the school year and culminate in participation in the event in late May 2010…”

Case 2: “Robo-poly”

“*Robo-poly*” is a project for introducing robotics in primary school designed by teachers who had attended the TERECoP training course in Athens (Terzidis et al., 2009). It includes a series of learning activities which are aimed to familiarize pupils with robotic systems and to allow them to acquire skills of construction and programming within a supervised environment where they can express themselves freely and enhance their creativity. The project was implemented in a year 4 class of the 2nd Primary School of Pallini, Greece, as an extra curriculum activity. The project was divided in three stages:

- Engagement: introduction to basic concepts;
- Experimentation: playning the Robo-poly game (to acquire basic skills);
- Creation: helping the “baby turtle” to reach the sea.

During the *engagement stage*, students were involved in introductory activities such as:

- discussion about what a robot is;
- assembly of the robotic device: students, in groups of 4-5 constructed a vehicle by using instruction sheets and teachers’ guidelines;
- basic movement and control commands: basic programming blocks were introduced by the teacher.

During the *experimentation stage* students were introduced to the basic concepts of programming in a playful manner. They were asked to play the game *Robo-poly* as reminiscent of the “*Monopoly*” game. The game was made up of 20 cards with tasks organized into three levels of difficulty. The goal of the game was for each team to gather 100 points. The goal could be achieved by using a variety of different card combinations. At the end of each activity the students presented their solution to the rest of the class.

Then, students were asked to give a solution to the open-ended problem: “Helping the baby turtle to reach the sea” (*creation stage*). According to this scenario students were asked to drive a just born baby *Karetta-Karetta* sea turtle (i.e. their robot) safely to the sea. The activities performed during that stage included: introduction of the scenario through a short story, creation of a poster based on the symbolic elements of the story, discussions, planning and solving the problem, presentations, and evaluation.

The familiarization and experimentation stages were aimed to familiarise students with robotics and programming and extend their abilities in dealing with this kind of technologies. The creation stage gave them the opportunity to utilize all skills and knowledge gained during the previous stages in a problem solving situation. The students were very enthusiastic and they participated creatively in all stages of this project. All groups worked and presented their work. The teachers tried to guide students in their exploration in a constructivist manner: asking questions, facilitating discussion between members of the group or between groups. At the end of the school year, in June 2009, the entire class referred to this experience with robotics as if not the best, one of the two most favoured activities.

Case 3: Motion and control

This project was implemented in a secondary school of Athens, Greece (3rd Gymnasium of Glygada) during March 2009. The project lasted for 12 teaching periods (45’) and it was developed as an interdisciplinary project combining Technology, Mathematics and Computer Science. It was the result of the cooperation of teachers from different disciplines: Maths, Computer Science, and Technology. One of the teachers had followed the TERECoP training course while the other two had attended a 6 hours seminar on educational robotics. The class teachers designed all the activities according to their curriculum objectives with some support and suggestions from a member of the Greek TERECoP team. The aim of the project was to familiarize students with robotic technologies (construction and programming skills) and to stimulate them to explore basic mathematics and science concepts about motion like displacement, circumference of a circle, length of an arc and proportional quantities. The main idea of the project was that students construct and program a vehicle which could move on a specific route.

Initially students decided on the path that their vehicle should follow and agreed on the themes/topics they were going to further explore (*engagement*). Then, students working with Lego Mindstorms constructed a robotic vehicle with several sensors able to move freely. Two guided experimentations aimed to help students to understand displacement and the changes in the direction of the vehicle (turns) (*exploration*). Students were encouraged to investigate the relation between the rotations of the motor and the change in direction of the vehicle to the right (angle of 90 degrees) (*investigation*). Students were also provided with a mock up of the vehicle route and they were asked to program their vehicle to move on that path. All groups used a light sensor to control the right turn of the robotic vehicle (*creation*).

During the engagement and exploration stages students worked with worksheets on guided activities. Specific questions guided their observations, measurements and calculations. All students performed very well in those tasks. Poor performances were observed in tasks looking for explanations requiring the use of concepts from mathematics like the formula of circumference. Students also performed quite well in the programming tasks (made their vehicle to move all along the proposed path). In the given time two groups out of six came up with a solution close to the initial plan agreed at the engagement stage. One group proposed a quite correct solution with a small error in the chosen turning parameters. Two groups did not take in consideration the physical characteristics of the construction (the position of the light sensor on the vehicle). The last group managed correctly each action of the final task (moving straight, turning to the right) but didn't manage to use these actions in a coherent manner.

Implementing robotics in classrooms was in the case of the 3rd Gymnasium of Glygada an innovation. Important factors that effectively supported that intervention were the positive attitude of the principal of the school, the collaboration between the teachers and the external support by a researcher (member of the TERECoP team) during the design and application phase.

Conclusions and recommendations

Robotics in Teacher Training: "teachers teach as they are taught, not as they are told to teach"

From the evaluation results it appears that our trainees appreciated the project-based learning method that they followed in their work and the exploration, experimentation and creation features included in that method. They appreciated also as "the best thing that happened to them during the course" the practical activities, the creation of engineering artifacts and their programming work ("*We experienced the joy of creation… when we built it up and it was operational*"). It appears, indeed, that they enjoyed their work with robots ("*When, ultimately, the robot moved along a square on the laboratory floor we rejoiced like young children*"). Their preference for practical work and their negative attitude towards "*theoretical presentations*" was also clear from the fact that they recorded among their negative experiences the cases where, because of lack of adequate training time, their practical work was substituted for theoretical discussion. Although the training methodology ensured trainees' active participation in practical activities, some of them requested even more practical activities and fewer presentations. Several trainees told us that the educator's axiom '*teachers teach as they are taught, not as they are told to teach*' emphasised by the trainers was really followed in the course. They admitted that they had a real experience of constructivism ("*It was for me a lesson of knowledge construction*", "*Constructivism was present all the time in the course*", "*this course was substantially different from the courses I had attended in the past*").

A practical difficulty encountered was the fact that the time available for face to face training sessions was usually limited and not enough for trainees to develop their team projects. They needed longer time to cooperate within their groups beyond the course sessions. It means that extra equipment (Lego Mindstorms sets) must be handed in each group for the necessary period of time and appropriate time arrangements must be anticipated in the schedule of the course that will allow the groups of trainees to work cooperatively at their own private time and place before they come back to the course to present their final products.

One of the main requests from the teachers concerned examples with a clear didactical content. In some cases we found that teachers were not interested in directions for building a new fancy robot or a robot with a cool behavior. They perceived this as out of the scope of their duty. They preferred to have a set of lab activities closely linked to their teaching subjects. We realized that designing such a set is not easy task and can be very tough for a teacher without previous educational robotics experience. Therefore, we tried to produce a variety of such experiences, and we intend to put as one of the main points of a future project the realization of a repository of several didactical experiences organized by curricular subject and learning objectives.

Another problem identified concerned the collaboration of teachers from different disciplines. Robotics projects are usually introduced as interdisciplinary activities. However, the cooperation between teachers from different disciplines is not usual in our school practice. We noticed that for example teachers of arts and humanities not only have difficulties in approaching robots as teaching tool, as one might expect, but also they have difficulty (or poor will) in collaborating on a project with the teachers of science or technology. Teachers seem also to worry about the management of big classes during the implementation of robotics-enhanced activities in school settings.

Robotics in School Classes: bringing the Logo turtle from the screen to the real world

Logo programming language and logo-based environments have been used for years as tools intended to introduce constructionism in classrooms. Our experiences emerged from the aforementioned cases and from several other similar activities carried out during the 3 years of the TERECoP Project (Alimisis, 2009), indicate that, educational robotics is a possible 'present & future' for constructionism theory and practice at the “beyond Logo” age. Educational robotics brings the Logo turtle from the screen to the real world and offers some key advantages: students can use robots not as a “virtual creatures” or as ready-made mechanical devices but they can build and program their own constructions and a wide variety of creative machines. Educational robotics might be seen as a vehicle of new ways of constructionist thinking and a vehicle driving to new paths in constructionist learning. It enables children (and educators!) to design their own instruments for meaningful investigations engaging them in new ways of learning in close connection with their interests and passions and providing a deeper and more concrete understanding of scientific ideas and a richer sense of the interplay between science and technology (Resnick, 1998). As a Greek teacher, who was supported by TERECoP to introduce robotics in his classroom, reported “*through these projects students get involved enthusiastically in learning activities that in traditional teaching situations would be boring for them. For example learning a mathematical formula to calculate an angle or a distance suddenly became an extremely interesting subject…*” (Giannakopoulos, 2009)

Our experience from the TERECoP activities in schools showed that when teachers are supported appropriately by trainers and their school authorities, they can find ways to introduce robotics in school classes as an interdisciplinary project. However, it is not always easy to integrate such approaches within the current school curriculum. This integration demands not only a lot of school time, but also changes in the official curriculum and a great investment in terms of the necessary equipment. So, a critical issue for integrating robotics-enhanced projects in the schools is how an interdisciplinary project may fit to the current school curricula and schedules. Interesting ideas were proposed for integrating educational robotics in schools such as working out interdisciplinary projects or research programs running out of the school everyday schedule in the form of after school classes.

As other teachers trained by TERECoP and involved in robotics activities in their class put it “*within the current curriculum, our students had not the time necessary to design, to experiment with, to program and to try their models…Due to the large number of students in one class, there* *was not enough room for all of them to work efficiently in groups. The teachers involved in this project were not willing to spend more time so as to experiment with the techniques or to use such activities in their everyday teaching practice. The majority of students could not find time available to participate in our project due to their busy afternoon schedule….We finally decided to form a group of 6 students who would work on robotics and eventually would participate in a robotics competition. We strongly believe that the competition motivated our students and stimulated their interest….Their parents' attitude towards the whole project was positive and supportive and that helped the team*" (Bakamitsou and Tsitsos, 2009). Once again, the combination of school activities with events happening beyond school seems to offer extra motives to students and makes their work more meaningful since the public event offers the opportunity for students and teachers to present their projects to a wider audience beyond the walls of their school class.

It is well known that in addition to the activities that take place in school settings, many other robotics events run in informal educational contexts, structured as competitions or exhibitions. The mission of the competitions is usually to engage young people in exciting mentor-based training that builds science, engineering and technology skills, inspire innovation, and foster self-confidence and communication skills. Robotics contests and the relevant project work appear as a very suitable platform to support team-based learning, which is often undervalued in the current school systems (Petrovič and Balogh, 2008).

In addition to teacher training courses and implementations in school classes, the TERECoP partnership organized successfully "European open days" on educational robotics (Venice 2008, Navarra 2009) and participated in exhibitions ("Discovery on film", Rovereto, 2007, 2008,2009). The European Open Days on Educational Robotics involved local educational authorities, schools, universities and companies and offered a forum of reflection about all the opportunities that robotics can offer for schools and students. During those "open days" teachers and students were provided with the opportunity to present and exchange experiences in a public place, to get in contact with associations and companies activated in educational robotics, to participate in round tables, to exhibit their models and to compete each other with their robots. We found very supportive for those activities the development of "local alliances" with institutions and companies involved in teacher training and in the promotion of creativity and innovation of the future citizens (Arlegui and Pina, 2009).

Our experiences from those open public activities showed that organizations external to the scholastic system like after school classes, clubs and centers equipped with robots, PCs, software and staff can stimulate and support teachers and students to develop their own personal or team robotics projects. These centers might be set in a network at regional or national level for an exchange of experiences and "know-how". All these promising initiatives like robotics competitions, exhibitions and "open days" complete the scenario of possibilities for the future years.

Epilogue

In addition to the aforementioned training and learning goals, the TERECoP partnership has been working the previous 3 years to build, through our robotics activities, communities of teachers activated in educational robotics at local, national and European level having achieved some remarkable results in Greece, in italy, in Spain and in the other participating countries and we intend to continue this work in the future. Finally, we aspire, exploiting the already gained rich experience, to continue to contribute to the further development of the dialogue within the broader European and international community of educational robotics, especially under the light of constructionism theory.

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