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Lessons Learnt From The TERECoP Project And New Pathways Into Educational Robotics Across Europe

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Robotic technologies in Education: beyond constructionism

C. Kynigos

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Construction and control were the first powerful ideas on the use of computational media for learning (Papert, 1980). With respect to digital media, this idea involved the transition from black-box software to the design of transparent (white-box) digital artifacts where users could construct and deconstruct objects and relations and have a deep structural access to the artifacts themselves (diSessa, 2000, Resnick et al, 2000). It also involved the idea of distributed control where multiple users worked with the same digital artifact either in presence or remotely from different computer screens so that they would express their ideas in collectives rather than work individually (Mor et al, 2006). However, the existence of such media did not bring about the envisaged radical changes in learning environments based on their use (Papert, 2002). Students fell onto 'plateaus', unable to progress beyond a certain point and found that they could not construct something very interesting when starting from scratch every time. To address this problem, black-and-white-box design perspectives provided users with generic black box artifacts which they could then use as building blocks for their constructions with exploratory digital media (for a discussion see Kynigos, 2004).

In the use of robotics, we saw a parallel transition from black box situations of pre-programmed pre-fabricated robots aimed for the workplace to transparent designs where children can construct and program robots from scratch. However, there has been little or no attention given to distributed control and black-and-white-box solutions where students can start from something complex and interesting and then move on to learning by constructing robots and programs to control them. This is the issue we are addressing in an informal educational games centre in Athens, called ' Polymechanon'.

So, what kinds of learning can be nurtured in learning environments based on the construction, programming and control of robots? What meanings and concepts can be understood in such environments? Do they afford added value to the fostering of creative thinking?

The main learning theory which has been perceived as useful for addressing the questions has been that of a special kind of constructivism termed 'constructionism' by Papert and his group at the Media Lab (Kafai & Resnick et al., 1996). Constructionism can be seen as a special case of learning in situations where we make or tinker with an object or an entity. It was seen by Papert as one of the ways in which thinking can be manifested, made public. Constructing was seen as an emergent activity where a lot of back and forth went on, where design is part of the process of building rather than a pre-requisite and where building involves de-construction and re-construction rather than just construction (Kynigos, 1995). Constructionism was elaborated in the early eighties at a time when individualistic cognitive theories were at the forefront and was thus associated an individualistic perception of learning. However, notions of collaborating and communicating during constructivist activity were firstly articulated as far back as the mid eighties (Rogoff & Lave, 1984) and have since become more and more pertinent as digital technologies have made it possible for more than one students to have access to the same construction at the same time (Mor et al, 2006). This has not however happened yet with mechanical technologies and robotics.

These perceptions of learning seem to fit very well with the activities of constructing robots and programs to control them. The robotics industry, however, aims at humans using pre-programmed pre-fabricated robots to do arduous, repetitive, mundane, fast, precise, dangerous or physically impossible things form them. The ways in which the robots are made and programmed is a black box for their users. It is the same paradigm with which many technologies are constructed from hardware to software and digital tools. It is also compatible with the traditional educational paradigm of the teacher or the curriculum book revealing and explaining ready-made ratified and thus unquestioned information.

In the framework of progressive and contemporary educational paradigms, construction and programming of robots have been made transparent so that individuals can engage in building and in programming robots themselves. Two main technologies have been so far designed and built for students to engage in robotics, the Lego-mindstorms and the Pico-crickets kits from the Media Lab at MIT (Resnick et al, 1996, Resnick et al, 1996b). This white-box metaphor for construction and programming has generated a lot of creative thinking and involvement in learners mainly in informal educational settings. However, as in the case of digital media, there seems to be a plateau which learners reach with respect to what kind of robots they make and what they can program them to do. It quickly becomes very difficult for anyone to construct a technically robust and interesting robot and to program it to do complicated and interesting things. This was noticed some time ago as in the case of Pico-crickets were there was an expansion of the kinds of sensors and the kinds of constructions students could make (Martin et al, 2000) in order to enhance for instance the interest of female students.

An important part of learning with robots, apart from constructing and programming them, is controlling them or their environment in play. This has been rather under-exploited from an educational point of view precisely because of the white-box metaphor of starting from scratch with robotics. Controlling robots however, can provide an avenue for black-and-white-box perspectives where students can have distributed control of specific robots in amongst others. This is seen as part of a complex learning environment also embedding the construction of robots and programs to control them as usual but different in that there is also emphasis on interesting learning activity with robot control.

In this talk, I consider robot control as an integral part of constructionism and describe and discuss a series of interactive exhibits designed for learners to control in interesting game situations and made available at a special informal serious games centre in Athens which we call 'Polymechanon'. I suggest that robot control can be perceived as an integral part of constructivist engagement with robotics and that given devices and setups where control is designed to be interesting, students can learn from the kinds of feedback they get from their activities and intentions to control the robots or their environment and from the kinds of representations available to them for control.

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TERECoP project: the French experiment

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1. Presentation of the French training course

The group of trainees for this project was constituted of second year students from the French Teacher's Training Institute (IUFM) where the TERECoP project took place.

The group was composed of students from different academic disciplines (technology, mathematics and physics, engineering and design) and teaching at different levels (secondary school and technical secondary school).

We will see that they didn't encounter the same difficulties in implementing the projects they designed in their classroom, due to their different backgrounds.

We used the TERECoP project as part of their curriculum to become teachers, as they have to produce a professional report consisting in driving a study from an identified situation relative to teaching.

In the course of this professional report, students usually implement a course in their classroom (they teach part time for 6 hours a week during their training) and analyze the results. Therefore, the training of our students followed the organization given in the table below:

TERECoP		**Professional report**
Presentation of the project	Teaching contract	Professional report
	The theoretical framework	
Use of the software and of the hardware		Problematic
Implementation and analysis of an example of device		
	Production of the educational sequence	
	Evaluation and regulation	
	Experimentation in class	
		Analysis of the observations
Training evaluation for TERECOP		Writing of the professional report
		Oral presentation by the students of their work

As part of their final evaluation as teachers, the students have to present their professional report in a written form (see following plan)

Title
Introduction Question treated
Content of the report
First part Theoretical frame
Problem treated
Proposed course
Knowledge and skills aimed
Public (class, subject…)
Second part Presentation of the whole course
Third part Analysis of the course observations
On the course
On pupils activities
On the teacher's activity
Conclusion Return on the initial question
Proposals
Bibliography
Appendices

The constraints for this training project were the ones defined by TERECoP. So the student's training was based on the construction and the programming of a robot using the Lego modular material and the software Mindstorms NXT.

It was organized around an approach in five stages: commitment, exploration, research, creation and evaluation.

The same constraints guided the trainees in the design of their own educational sequence.

2. Presentation of the students' projects

Four different projects were conceived by the students, depending on their academic discipline and their level of teaching, and these projects were then tested in class with pupils.

- **Robotics challenge – (technology teachers, secondary school)**

Challenge: A robot has to go from A to B either through a labyrinth with colored walls (white when the path turns left and black when it turns right) or following a black line on the floor.

This activity was implemented in a classroom of 28 secondary school pupils, aged 12-13, in the part of their technology course treating of "computer aided piloting".

- **Automated camera – (design teacher, technical secondary school)**

In order to follow and film the progress of a flask on an automated production line called "ERMAFLEX" that fills, packages and packs flasks of different types, a robot with an onboard camera will be used.

This project was designed for a group of 12 pupils of age 16, in their first year of technical secondary school in the field of "Maintenance of Industrial Plants".

- **Automation of a wheelchair – (maintenance teacher, technical secondary school)**

What problems can a disabled person meet in a school? What would they need to face up these problems? What are the possible the risks?

The public, in this project, was constituted of a half group (15 pupils) of a class pupils aged between 15 and 17, in their second year of technical secondary school in the field of "Service of Industrial Equipment".

- **Conveyer belt – (maintenance teacher, technical secondary school)**

Management of the automatic movement of the passengers and the luggage by conveyer belt (travelator) in an airport.

This project was conceived for a half group (15 pupils) of a class pupils aged between 16 and 17, in their second year of technical secondary school in industrial field and was to be used in the course of mathematics & physics.

3. Assessment of the TERECoP project, general remarks.

For the stage of engagement in the project the trainees had to define starting situations at the same time rich and justifying for the pupils. The difficulties met by the trainees during the elaboration of the courses to be implemented in their classrooms were principally due to the three following points:

- The choice of the knowledge to be treated
- The definition of the starting situation
- The temporal and material organization of sessions in class

On the other hand we noticed the following positive points:

- A strong implication in the project
- A richness in the work of the group of trainees due to their different academic disciplines
- An opening of the didactic reflection

4. Assessment of the different experimentations in class by the students

- **Robotics challenge**

The main difficulty encountered by the students in the course they had designed was passing from the description in natural language of the working of the robot to the programming in formal language.

- **Automated camera**

This project was implemented by two students-teachers one classroom and was compared to a more classic lesson treating the same subjects. The results of the comparison of the two different teaching methods (with or without the help of educational robotics) was presented by the student in their professional report as part of their evaluation as teachers trainees.

In this example the students had great difficulties in designing a course using a constructivist approach because it had to fit in a curriculum that was built around the logic of pedagogy by objectives (a behaviouristic approach).

So, unfortunately, in this particular case, they did not find any real benefits using ER in a constructivist approach over a more traditional teaching method.

- **Automation of a wheelchair**

At first, the pupils did not understand the problem to be solved, and then the pupils were also in difficulties with most of the written documents.

However, in the end, the pupils had become actors, and were really motivated to achieve a result.

- **Conveyer belt**

For reasons independent of their will, the students did not experiment in class.

5. Conclusion

In conclusion, it must be noted that the groups of students that followed the TERECoP course all produced professional reports that received very good evaluation.

They noted that the pupils’ engagement was much more important with the use of Educational Robotics using a constructionist method and they will try and use it in their teaching, although the building of such a course can be time consuming.

All these experiments in class were presented in a communication at the international symposium “Professeur de technologie, spécialité et formations” in Rennes, France (27/01/2009) and in a workshop in the French-speaking symposium of pedagogic robotics in Montreal, Canada (28/05/2009)

Educational Robotics in Italy:
future perspectives after the TERECoP experience

University of Padova, Department of Information Engineering (IT), IT+Robotics (IT), Town Museum of Rovereto (IT)

The group

The Italian National group in the TERECoP project is formed by three organizations: the Department of Information Engineering (DEI) of the University of Padova, the IT+Robotics (ITR) Company, and the Museo Civico di Rovereto (Town Museum of Rovereto, TMR). The collaboration of these three entities has proved as a good synergy of complementary competencies related to the main theme of the project, educational robotics.

In fact at DEI prof. Emanuele Menegatti belongs to the Robotics research group and had some previous experiences in developing educative examples with robots. Prof. Michele Moro joined in the past the Eurologo scientific committee and had experiences in the constructivist/constructionist approach in education. ITR is a spin-off company of the University of Padova whose main objective is the development of up-to-date robotic applications and the dissemination of the modern robotic culture both in the educational and professional fields. Since 1851 TMR has been involved in disseminating the scientific knowledge in several subjects (flora, fauna, astronomy, archeology, historical-artistic heritage of the city, data and materials archiving, and more recently pollution and study of the environment) through several permanent activities: supporting of research groups, promotion of a network of schools and other institutions in its territory active in the field, training courses for teachers, laboratories and external activities for students, expositions for the general audience, and it has been developing a specific track on educational robotics within its new dedicated educational section created in 1998. All these activities are supervised by the didactical section of the Museum (proff. Nello Fava and Stefano Monfalcon).

The training course

After the preliminary phases for acquiring the necessary prerequisites (the purchase of the robotic kits Mindstorms NXT and the collecting of a national/international literature on the subject), the Italian group worked on some work packages in order to define the training course curriculum, namely WP2 (criteria and description of the chosen Lego Mindstorms development environment), WP5 (Introduction of the course), WP6 (Worksheets on the software), WP9 (Preparation of the pilot courses), WP10-12 (Developing of the project web site and e-class), WP13 (Dissemination activity). In particular large part of this development was performed in strict relation with the Spanish partners. This common activity leaded to collaborating each other in the organization and conduction of the two pilot implementations of the training course, the one in Italy (at Rovereto) and the one in Spain (at Pamplona).

The course in Rovereto with about 15 trainees spanned two weeks (in October and November 2007) plus two evaluation meetings in December. The evaluation was performed through a questionnaire and group and personal interviews. The objectives of the course were:

- to build competences for designing educational laboratory project-based activities;
- to learn to use innovative didactic methodologies and technologies that the course proposed;
- to consolidate the ability of working in groups, also through the use of ICT tools;
- working on:
    - the realization of the proposed activities, with communication and guided groupbased work;
    - pedagogical and methodological reasoning on the educative management of the activity

An important outcome was the growing of a network of institutions working on educational activities enhanced on robotics. In the last two editions of Discovery (see later) ten teacher-trainees participated in a public exhibition showing robots and experiments realized with their students in the class. Some of them are now collaborating with the Museum in training other theachers and in dissemination.

Besides the implementations foreseen in the project workplan, the Italian group participated in the organization of a further implementation hosted by a high school in Bolzano (October 2008) with about 20 trainees, substantially following the TERECoP curriculum. The most important outcome of this activity is that the School Authority in Bolzano is working on introducing educational robotics in the curriculum of 1st degree secondary school of all the area.

The course in Rovereto

The course in Bolzano

Documentation and dissemination

In the final phases of the project all the main results have been summarized in the draft of a book to be published successively. Our group was responsible for the following sections: Basic knowledge to use robotics in education; Some reasons to use Lego Mindstorms NXT; LegoMindstorms NXT (hard- and software); Straight-line robots; Turning robots; Sensored robots; Data logging; Some relevant examples of activities to be realized with LEGO NXT or humanoid robots with a clear didactical motivation.

The dissemination activity was also intense and significant. Apart the maintaining of the project web site and the experimental e-class, the Italian group, partly in collaboration with other partners of the project, prepared some papers presented in international conferences (Eurologo2007, Edutec 2007, ISSEP 2008, Inted 2009, Syros 2009) and organized also a TERECoP Workshop of one day (November 3rd, 2008 in the frame of 1st International Conference on SIMULATION, MODELING and PROGRAMMING for AUTONOMOUS ROBOTS - SIMPAR 2008, see www.simpar-conference.org) where it presented 2 papers. The workshop run on November 3 in the beautiful palace of Telecom Italia Future Centre in the city centre of Venice, Italy. The workshop had over 30 registered people (only 15 were TERECop partners) and about 20 submissions, 15 papers were published in the workshop proceedings. In the same location of the workshop on November 7, we organized a public exhibition in which we invited a selected number of teachers to bring their students and the robots they realized in their schools for showing them to the general public. We had more than 10 schools participating from the Triveneto with more than 60 students presenting more then 30 robots of different kind and size. During the exhibition we run a workshop targeted to the school teachers in order to disseminate TERECop activity and to promote a coordination on educational robotics among the participants.

Every year TMR organizes 'Discovery on film', an event with a specific section dedicated to educational robotics where schools from every part of North Italy can expose their robotics-enhanced projects and attend to demonstrations and conferences leaded by researchers coming from various universities and research centres. In the last three years (2007-2009) the TERECoP group has had its stand where the course and the related developed experiences were presented.

We also participated in other meetings on the subject, namely: the final meeting of the national project "Robot@Scuola" in Padova (Italy - 20/10/06); a dissemination activity about mini-robotics at the educational complex of 'Collegio Pio X' in Treviso (13/02/07, 19/01/08 and 17/01/09); a meeting for possible collaboration with a group in Turin (IRRE Regional Institute for Educational Research of Piedmont, Italy) (Padova 2-3/3/2007); the final Robo-didactics project and the Seminar 'Educational Robotics' organized by CKBG (Collaborative Knowledge Building Group) Association and the University 'La Sapienza' (Rome, 29-30/9/2008); the European Open Day in Educational Robotics organized by our Spanish partners in Pamplona (28/4/09); the Open Day 2009 of the school network on educational robotics leaded by ITIS F.Severi (Technical secondary school) (Padova 28/05/2009).


The Workshop in Venice


The Open Day in Venice

The Discovery exhibition 2009 in Rovereto

Development

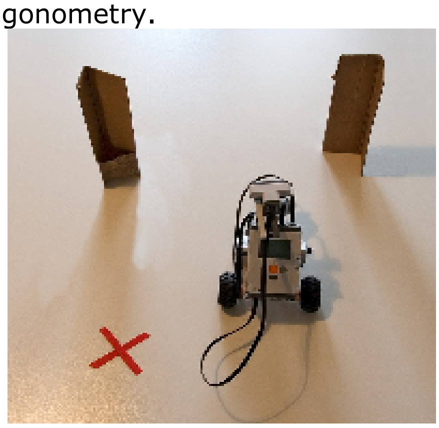
Thanks to the collaboration of several undergraduate students, we also developed representative examples using the identified robotic architecture and some further tools, here briefly listed. Among the experiences with NXT and its programming languages NXT-G and NXC: a sorter of coloured Lego bricks, an object avoider, a bar code reader, the Doppler effect, a self-positioner, the shadow (a study of some properties of triangles), a car parking system, some computer theory ideas (a AND/OR car, a Turing car, a DFA car), an artificial intelligent system (optical recognition of hand-coded commands), how to estimate the distance of two object (application of the cosine theorem), another bar code reader, how to estimate the constant of a spring, small brick sorters (selection and heap sort applications), two experiences on astronomy (planet motion and lunar lending), a replication of a segway, the robotic replication of the 'Encierro' run of Pamplona, Spain.

We took the opportunity also to start the development of a simplified simulation of the NXT hardware able to load an RXE executable file (produced through the NXT-G environment or the NXC compiler or somehow else) and to control and reproduce its execution, including the simulation of servomotors and some basic sensors. We also developed a proposal for a remote laboratory based on free software and a browser-oriented client.

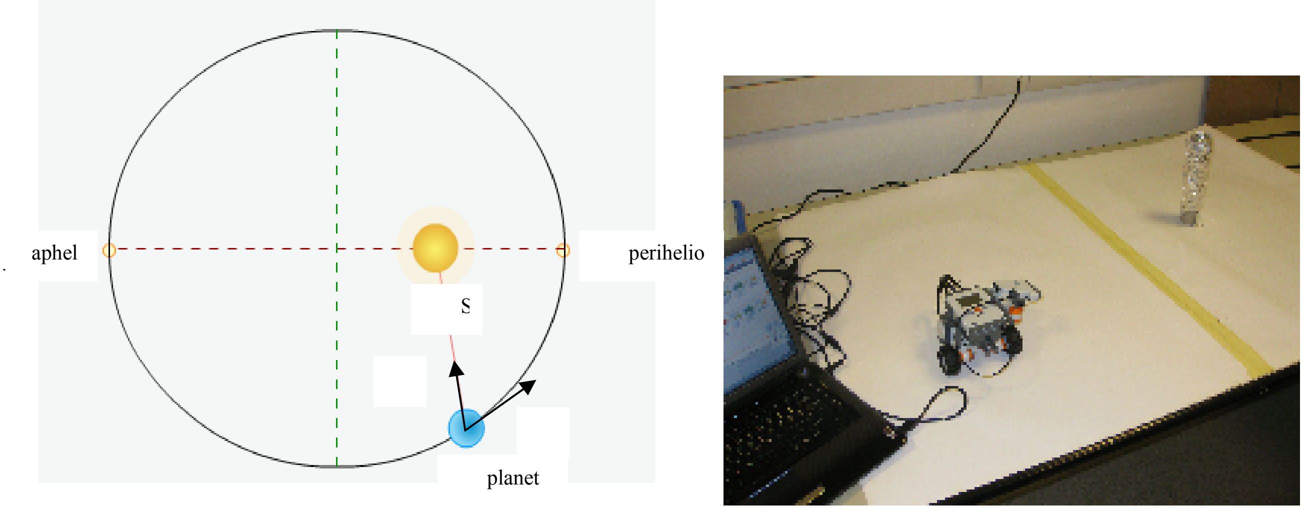
Other activities were: experimental analysis of the main NXT sensors; studies about other ways to control NXT (with different languages/environment like Logo for a NXT 'turtle', Lejos-Java, Ruby, URBI, MRS – Microsoft Robotic Studio, on a PDA through Bluetooth), how to localize NXC, how to develop new sensors through the I^2C interface.

Finally we bought a small humanoid robot kit and made a couple of early experiences to demonstrate the educational value of this architecture. Small humanoid robot kits represents a possible future substitute (or integration) of the more traditional and more economical solutions used up-to-now to develop robotic-enhanced educational activities. We realized a tool to support the study of foreigner languages (mainly in learning the vocabulary related to the human body and its motions) and an interactive experience for the study of trigonometry.

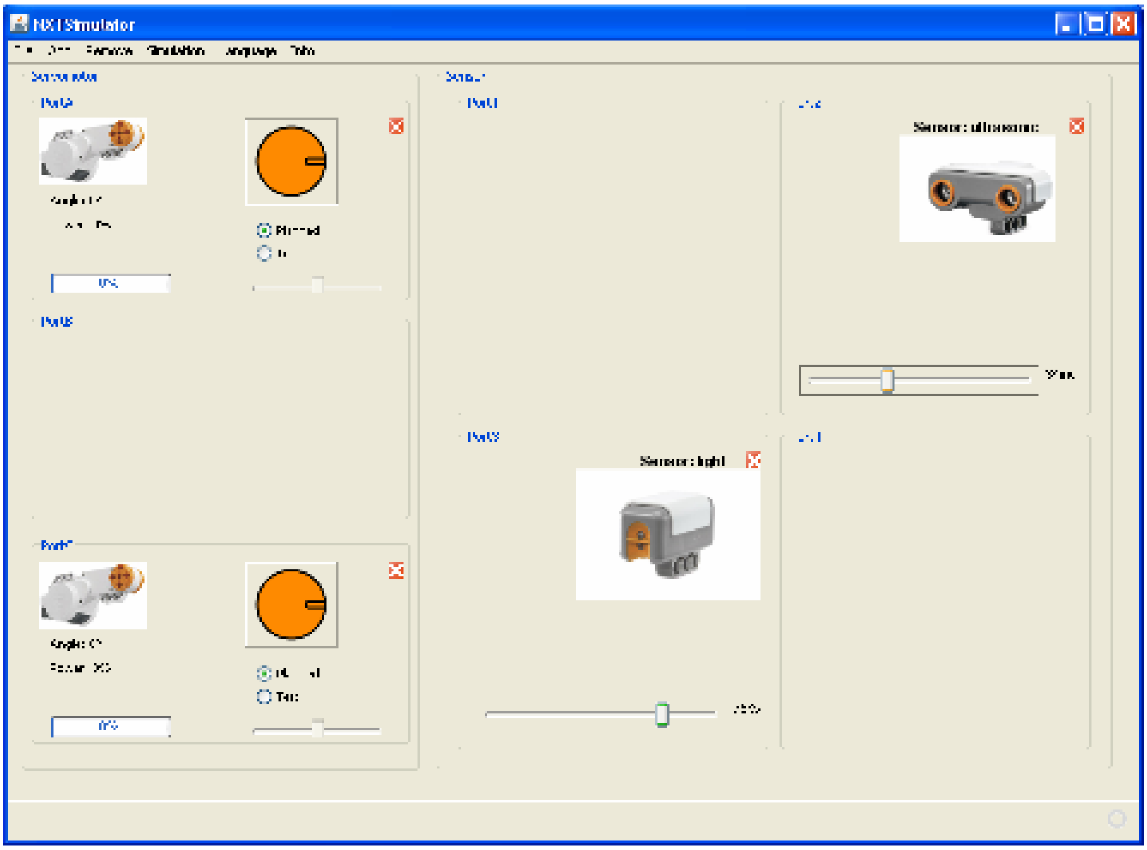
The AI-based hand-command reader



The Positioner



The Planet



The NXT Simulator graphical interface

Lessons learnt and future activities

The first thing we realized working with school teachers is the fact they prefer practical activities with respect to theoretical lessons. They do not like to be taught, on the contrary they would like to be guided and trained. This is very much in line with the constructivist approach we followed in this project. However, they are not used to exploit a constructivist approach in their daily lessons in the class, probably because they do not know its deep motivations and its educative value.

One of the main request from the teachers was for activities examples with a clear didactical content. They are not interested in directions for building a new fancy robot or a robot with a cool behavior. They perceive this as out of the scope of their duty; and this is right. They would like to have a set of lab activities strongly linked to the subject they are teaching. We realized that designing this is not easy 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 would like to suggest to put as one of the main points of future projects the realization of a repository of several didactical experiences organized by curricular subject and main educative objectives.

Teachers, at least most Italian teachers, are not confident with the design and implementation of practical activities in the lab for the students. Thus, they ask to have guidelines, and maybe outlines of materials, documentation, tools to be used with the students in the practical experiences. This is quite normal for teachers used to transfer knowledge 'ex cathedra' and to consider themselves as 'depositary' of the knowledge that ought to be taught. On the contrary constructivist project-based learning implies a sharing of responsibility between the teacher and the student to reach its educative objects, particularly by means of direct experience during laboratory activities.

We noticed that teachers of arts and humanities not only have difficulties in approaching robots as a teaching tools, as one might expect, but also they have troubles (or poor will) in collaborating on a project base with the teachers of science or technology. We do not know if this is because of robotics or because in Italy is not so usual the cooperation between teachers of different disciplines.

Another problem we encountered is the choice of the robot kits. For many schools the cost of the LEGO Mindstorms kit is too high. For the kids of primary schools the LEGO Mindstorms kit is too advanced and they need simpler robot kits. On the contrary, students of secondary schools many times feel the LEGO Mindstorms kit is too childish and somehow limited in its capabilities. Many teachers in technical secondary schools would like to make the students build not only the mechanical part, but also the electronic part of their robots and to have a deeper insight in technical aspects like mechanics, control theory, programming, etc. For all these reasons the choice of the robot kits is not trivial and foregone and should not be unique. The field of robotics and the one of educational robotics is rapidly evolving and we are convinced that in few years more numerous, advanced, and convenient robot kits will be on the market. Teachers will have to choose among new possibilities.

When we tried to organize a further training course in Treviso during 2009, it was necessary to delay this implementation due to current financial limitations. Indeed, we discovered that in Italy teachers are not willing/able to pay on their own a registration fee (of about 150-200 euro) necessary for covering the cost of the course. The teachers' schools do not want (or cannot) pay the teachers registration fee for long-life learning courses. Moreover, in Italy teachers are not rewarded in any way for participating in advanced training courses, there is no incentive for them to participate in such courses neither monetary nor in terms of career advances.

For all the presented reasons, we feel that any implementation of the course should take into account the peculiar local school context and teacher audience. The main point is to convey to teachers the methodological method and to give them motivations for applying robotic technologies within their normal curricula. Even if in a 30 hours course we cannot have experiences with a variety of robot kits, the existence of other robot kit should be presented and we should give hints to the teachers on their advantages and applicability over the reference platform, that at the moment is LEGO Mindstorms NXT.

Some organizations external to the scholastic system could give an effective support in introducing educational robotics in the learning process promoting centers (club houses) equipped with robots, PCs, software and staff giving advice, where students after normal school can be stimulated to develop interesting projects, singularly or in teams. These centers could be set in a network at regional or national level for an exchange of experiences and know-how. Other promising initiatives like the First Lego League, RoboCup Junior and LECs (Lego education centers) complete the scenario of possibilities for the future years.

Robotics and the Competences Oriented Education

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One of the most debated aspects of the education in Europe is the orientation of the educational systems rather on competences acquiring than knowledge accumulation. A competence is a combination of knowledge, skills, attitude and personal characteristics which are used by a person to function towards the demand in a certain domain. Under these circumstances, some specific instruments and pedagogical methods should be used to reform more or less the educational concepts across the Europe.

The main idea is to find the most appropriate ways that move the acquired knowledge towards the operational knowledge for many disciplines into different learning areas. On one hand, the constructivist approaches are able to reformulate the curricula in that direction, and to improve the didactical functions on the other hand. Lessons learnt from the TERECoP Project contribute focally on basic concepts developing in area of the competences oriented education. In particular, it is relevant to discuss how the robotics helps the competences based learning. A general overview on this issue can be illustrated in Figure 1 and points out where the robotics would have an impact in the learning process.

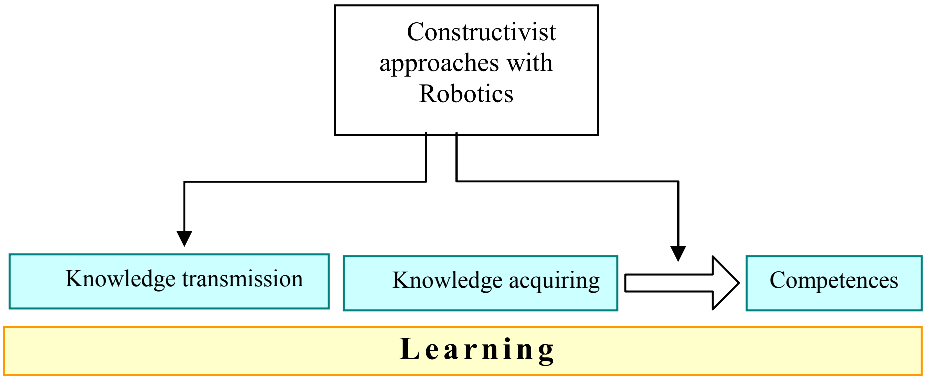

Fig.1. Learning process

We find the most important impact of the robotics on the competence oriented education occurs early during the knowledge transmission that is crucial for building of the concepts. This is the key stage for further process towards obtaining of the competences. We sustain the idea that improving certain didactical functions by means of robotics would pave the way on competence building in various disciplines. The functions that we consider playing a key role in the competence oriented education are following: motivational function, instrumental function and cognitive function.

Our contribution brings some examples of application with robots that aim to consolidate certain competences as the combination of right knowledge, skills, behavior or attitude.

Future teachers of ICT get prepared for using robotics in a constructivist apprehended education: Czech experience of running courses TERECoP and from related activities

Charles University Prague, Faculty of Education, Czech Republic

The paper summarizes the experience acquired during the implementation of a course, focused on the preparation of future teachers of ICT - the experience that may be exploited in teaching robotics and theory of constructivism. The paper also describes other activities undertaken in connection with the course, e.g. actions designed to promote the concept of using edurobotics in schools and among public, or a process of a controlling practical education in elementary schools, organized in the context of a model curriculum project TERECoP. The realized activities are assessed; then, on the basis of the gained knowledge and experience, proposals for some additional actions are put forward. Such actions could be executed in the preparation of teachers, who are interested in using constructivist edurobotics (e.g. use of media, creating digital learning materials, teaching practice, etc.).

Teacher training in the scientific field through robotic activities

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1. Introduction

In this paper we make a reflection on our experiences through the TERECOP project. First we describe the methodological and technological approach we have been used. Then we outline our experiences in the training pilot courses. In the next 2 sections we present 2 "external" activities we have undertaken among our activities. Finally we give some conclusions.

2. Methodological and technological aspects

2.1. Learning strategy

The constructivist theories of Jean Piaget argue that human learning is no 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) [1]. On top of this, the constructionist educational philosophy of S. Papert added that the construction of new knowledge is more effective when the learners are engaged in constructing products that are personally meaningful to them. Constructionism (Papert 1992, Papert 1980) [2] [3], is a natural extension of constructivism and emphasizes the hands-on aspect. Vygotsky's (1962) [4] theoretical framework stands that social interaction plays a fundamental role in the development of cognition. Another aspect is the idea that the potential for cognitive development depends upon the "zone of proximal development" (ZPD): a level of development attained when children engage in social behaviour. Full development of the ZPD depends again upon full social interaction (teacher guidance or pupil collaboration). The expertise (to attain competent skills) in "commanding tasks to robots so that they have certain behaviours (with a goal in mind)" can be the object of constructivist education (on the teacher's side) and constructivist learning (on the student's side). For this we have to select and adapt to our objective the most pertinent characteristics of the theories of Piaget and Vygotsky, known as cognitive reconstruction theories assuming a constructivist education-learning.

The design of good education-learning experiences (constructivist ones) with robots has to be done taking into account the following points:

- Proposing to the pupils different "classes" of problems to solve (tasks of a same class); the itinerary to follow has to produce a meaningful learning and needs to have an adequate sequence of learning problems according to the pupil's knowledge and profile.
- Cooperating, teachers and pupils, for the resolution of the class of problems in the "zone of proximal development" (Vygotsky)
- Integrating finally every class of solved tasks in technical or technological procedures more general and abstract.

2.1. Methodology

Then it is necessary to "tune" adequately the learning strategy and the learning tools in order to create the correct learning situation to the pupil profile. In our case we have chosen a PBL strategy to create a didactical situation based on exploration and enquiry learning, producing the adequate learning tools.

The problem-based learning (PBL) is a method that challenges students to "learn to learn"; student groups are seeking solutions to real world problems, which are based on a technology-based framework used to engage students' curiosity and initiate motivation, leading so to critical and analytical thinking [5] [6].

The main interest of PBL in our approach is that it allows us a different approach to curriculum and course design, crossing disciplinary boundaries, and tolerating a degree of uncertainty about outcomes. This can be an interesting way for us to deal with different education levels (for the moment primary and secondary) and to work on a curricula where robotics can be used both with scientific disciplines (Maths, Physics, Computing, etc..) and with others related with social sciences, linguistics, etc…

During the PBL learning process and within TERECoP several stages have been identified: engagement stage, exploration stage, investigation stage, production /creation stage and evaluation stage.

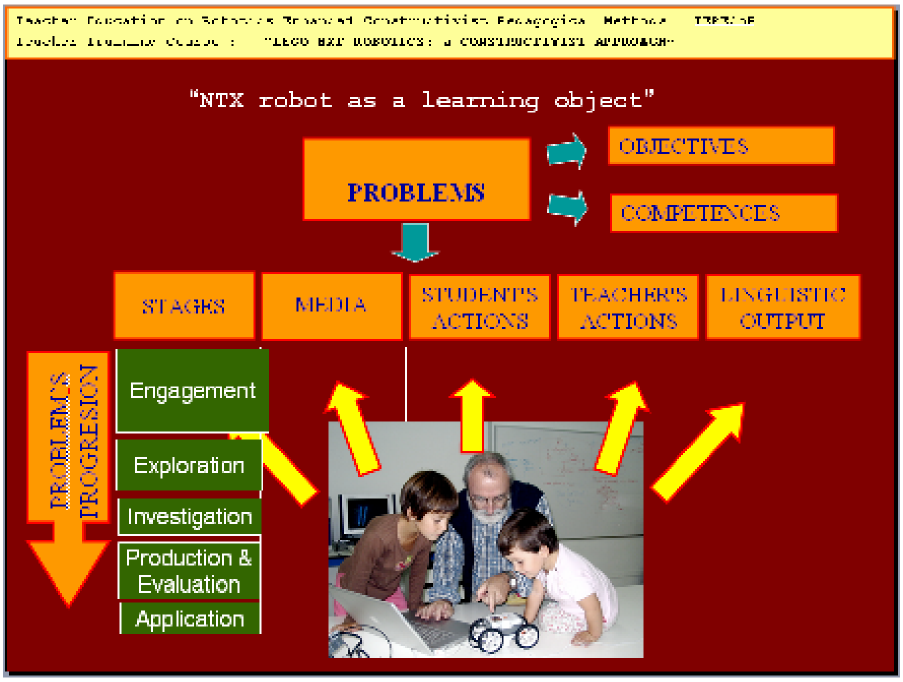

Fig. 1. Slide extracted from the material of the courses

2.3. Technology

We considered different robotic platforms that could fulfil these requirements:

- Several programming paradigms & levels
- Many degrees of complexity (to be able to use it in no university education levels, for example)
- Simple but significant extending possibilities (more sensors, hardware, interface, high level behaviour using AI techniques maybe using a PC as "remote brain" to provide more computational power to the robot, physics and maths simulation, data logging, etc….)

Our final choice was the NXT LEGO technology, because it fulfils the previous requirements and moreover it is possible to start working with it almost immediately (no electrical or other hardware or software arrangements are necessary). Another advantage of the NXT LEGO technology we are interested in is the different programming languages and programming environments available. For instance, with the NXT LEGO is possible to use the original LEGO graphical programming environment NXT-G, or the C-like NXC or the Java based LeJOS-NXJ (some of them requires firmware replacement). Moreover, one has the possibility to use several operating systems and/or platforms(URBI, Universal Real-time Behaviour Interface, for Windows, Mac OSX, Linux or NXT-Symbian running on Symbian 6.0 Java-enabled mobile phones).

3. Teacher training in the scientific field through robotic activities

In Italy and Spain the TERECOP Pilot courses [7] took place in November 2007 and April 2008. In both cases, the "trainers" were the partners of DEI (Univ. of Padova, Italy), UPNA (Public Univ.

of Navarra, Spain) and Rovereto Museum (Italy), and the "trainees" were (mostly) in-service teachers from secondary education level.

In the case of Pamplona, where several institutions were collaborating to organise it. The Public University of Navarra, the Supporting Centre for Teachers of Navarra (CAP) and CEIN (Public company which one of his activities is to promote creativity and innovation among young students) made it possible.

The courses aimed to reach two main objectives for the scientific education:

- to assure scientific competences necessary to face the nowadays world challenges;
- to design activities and curricula able to adapt disciplinary structures to the learning dynamics

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 the teaching of scientific subjects, making the trainees confident with the constructivist education following the aims of the TERECoP project.

These trainee's courses are only the tip of the iceberg; the most challenging issue is to manage to have some feedback from some of the trainees when being trainers of their own pupils, either in a formal learning context or in an informal learning context.

It is very difficult to include such approaches within the current curriculum in the schools, it not only needs a lot of time but also a change on the official curriculum of each country. Another difficulty is that a great investment is needed to start up.

4.- European Open Day on Educational Robotics (28th April 2009)

On the 28th of April we have organised an European open day to share and disseminate our experiences.

Our objectives were:

- To involve Education authorities. Schools, University, and companies in training students.
- To offer a forum of reflection about all the possibilities Robotics have in Compulsory Education (Primary and Secondary schools).
- To offer students an open place where they can exchange their experiences in Robotics.
- To provide the approach among society and robotics.

The Participants were:

- Teacher-student teams of primary and Secondary Schools from Navarra, Italy and Greece.
- Companies involved with robotics
- Students from UPNA
- CEIN
- Organisers of the First-Lego-league in Navarra

The main activities have been:

- Stands of teacher-student teams, CEIN-FLL and companies involved with robotics where they show their activities related to the subject.
- Barbara Demo lecture, expert in Robotics and Education from the University of Torino, Italy.
- Round table (working session) about the real and possible use of Robotics in education (TERECOP experiences).
- Robots pilot competition with Lego robots and/or other kinds of robots.

5.- First Lego League in Navarra (2008-09 and 2009-10)

The FIRST Lego League (also known by the acronym FLL) is an international competition for elementary and middle school students (ages 9-14 in the USA and Canada, 9-16 elsewhere).

Each year the contest focuses on a different real-world topic related to the sciences. There is a scientific project related to the topic of the year to be developed and presented. The robotics part of the competition revolves around designing and programming Lego robots to complete tasks. The students work out solutions to the various problems they are given and then meet for regional tournaments to share their knowledge, compare ideas, and display their robots.

Teams are allowed to only win one of the awards shown at Fig. 2. In this figure it is also possible to see the different parts of the tournament and the different stages and juries involved.

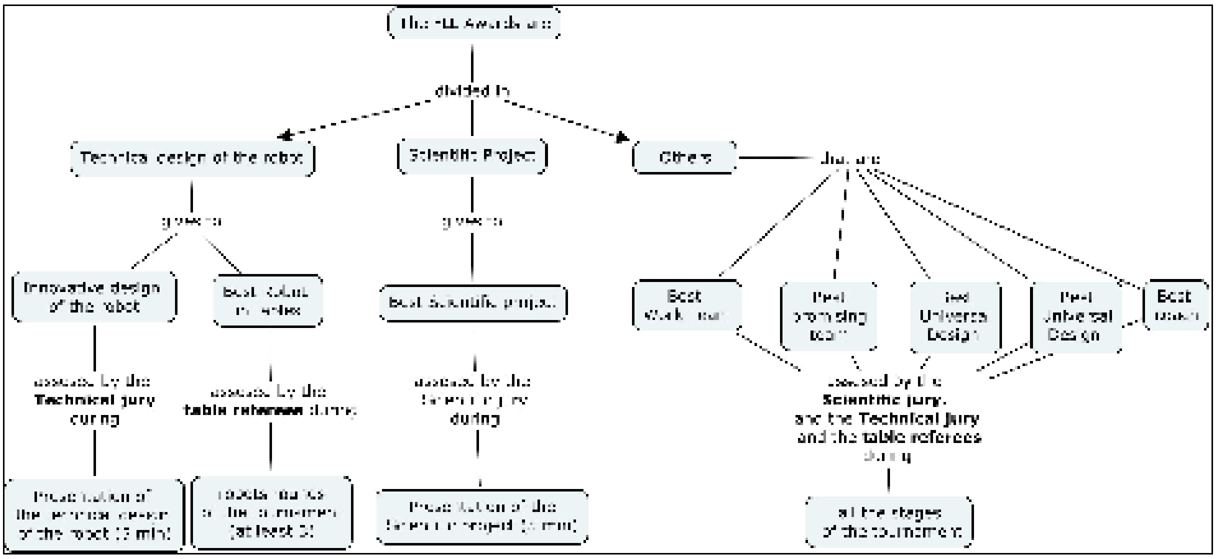

Fig. 2. A Cmap of the FLL (Navarra, Spain) 2008-09

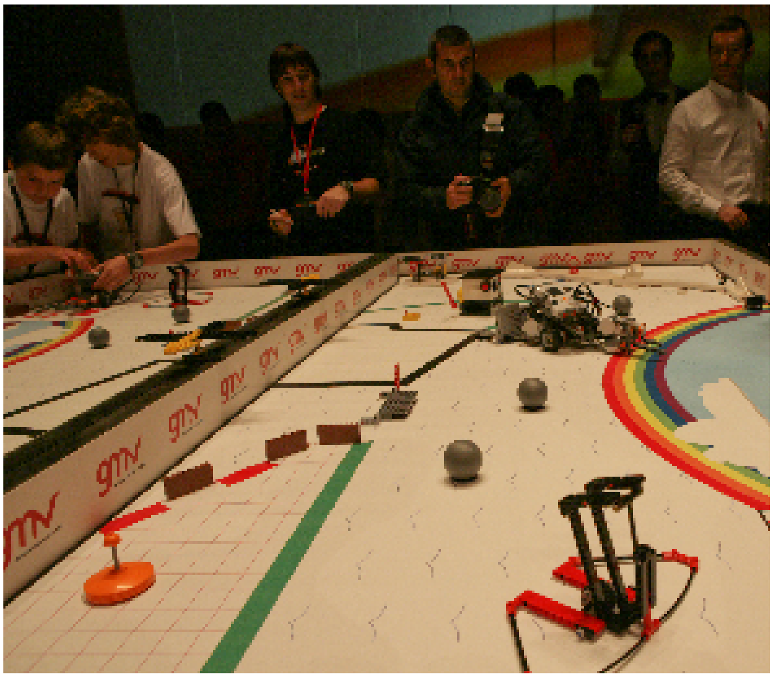

Fig. 3. At the FLL competition

15 teams from Navarra and 1 from Zaragoza took part in the first edition of the International First Lego League in Navarra that was done in November 2008 (previous round before the Spanish final of February 2009).

This year the challenge focuses on the earth's past, present, and future climate. Students must research a climate problem occurring in their area, find a solution, then share it. They also have to research another area which has the same problem as their area.

The robot is autonomous and completes missions on a mat where the missions are set up (see Fig. 3). The robot then has two and a half minutes to complete those missions.

6. Conclusions

Terecop has allow us to have a strong methodological approach and also provides us with a valuable network of collaborators, the partners.

We have managed to find very interesting local alliances. CEIN, a company involved in training at schools for the creativity and innovation of the future citizens, connects us to the industry and society world. As all the activities we have undertaken have been coordinated with Pamplona’s CAP (Official training centre for teachers in Navarra) they are in some way “official activities” and this is very important to motivate and support the teachers participating in such activities.

For the future we would like to continue with our educational robotic activities at schools, to be used at schools or out of the schools (robotic competitions, open days, etc.…).

We would like to be able to involve teachers and students from different educational levels (from primary to university), to coordinate the activities with the education department of Navarra Government and to share all these activities with society and industry.

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Challenges and achievements of the TERECoP[1] project: the Hellenic experience

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The TERECoP group in Hellas involved researchers and teachers from secondary and tertiary education. The national group followed the TERECoP work plan and was involved mainly in the following tasks:

1. Outline a methodology for designing robotics-enhanced activities within the constructivist learning approach for secondary school students: basic principles, learning objectives and strategies, learning activities
2. Development of training courses for teachers: design a pilot course curriculum, development of training materials
3. Implementation of a pilot training course for teachers
4. Development of e-class workspace for trainers and trainees
5. Development and maintenance of a website for the project
6. Dissemination activities: paper presentations and workshop organization in national and international conferences

The most challenging parts of the work were:

1st challenge: propose a methodogy for designing robotics-enhanced projects

The first challenge was to propose a methodology for designing a robotics-enhanced constructivist learning environment that could be communicated to teachers providing them with appropriate guidance for designing their own projects. The main principles of constructivism, constructionism and project-based learning were integrated in this methodology.

Designing a robot to do even a simple task can place extensive demands on students' creativity and problem-solving ability (Druin & Hendler, 2000). Building and programming autonomous robots is an ideal context in which teachers can situate a project-based learning experience where learners work collaboratively to understand the problem, propose viable solutions and construct their artefacts. It is quite important a driving question or problem to set the stage and the project context to allow for a multitude of design paths.

Stage	Description	Proposed Tasks
Engagement stage	Students may be provided with an open-ended problem and get involved in defining the project and main issues involved	Study of raw material such as newspapers, magazines, videos, stories, cases Discuss Express opinions/ideas Pose questions Negotiate Brainstorming
Exploration stage	Students get familiar with controlling devices and software, make hypothesis and test their validity in real conditions	Study samples of representative constructions/programs Observe Searching / Gather information Experimenting Collaborate / Negotiate / Argumentation

[1] 'Teacher Education on Robotics-Enhanced Constructivist Pedagogical Methods'

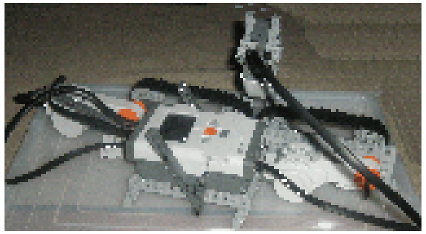
Investigation stage	Students formulate the driving questions / problems, investigate alternative solutions	Reflect on previously defined open issues Make hypothesis that they can test Planning Collect evidence Interpret Evaluate Keep diary Collaborate / Negotiate / Argumentation
Creation stage	Students share and combine their artifacts, synthesize 'solutions' to the initial problem	Evaluate previous work Share ideas Synthesize a product Keep diary Collaborate / Negotiate / Argumentation
Evaluation stage	Students share ideas & products at class level, evaluate final group proposals, synthesize the final product	Present their products Discussion Peer evaluation

2nd challenge: Communicating the methodology to teachers

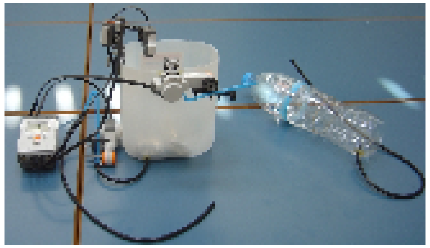
The central concept of the training course implemented in Greece was to build constructivist professional development sessions based on learning activities that teachers should be able to use in their own classrooms. Thus, the methodology for designing robotics-enhanced constructivist learning was also applied to the teacher courses.

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 participated 4 trainers and 23 trainees who were teachers in service (4 teachers of primary education and 11 of secondary education) and candidate teachers. During the course, trainees worked in a constructionist learning environment since they were actively engaged in activities, working in teams with peers. To enhance the sense of community and promote collaboration through the course an e-class was also maintained.

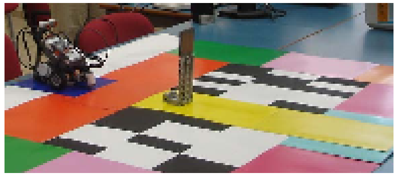
During the training course, trainees undertook multiple roles. They initially worked as students to familiarize themselves with materials and the programming environment, then they worked as teachers to reflect on the methodology for designing robotics-enhanced activities used in TERECoP and on the pedagogical 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.



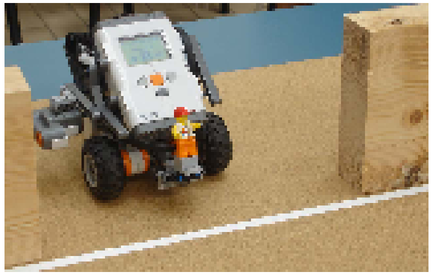
Project 1: ***Selector of recycled garbage***



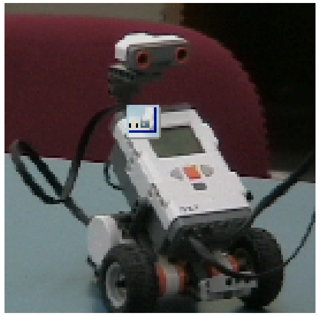
Project 2: ***Autonomous irrigation system for water management***



Project 3: ***Organizing seats in a theatre***



Project 4: ***Easy parking***



Project 5: ***A moving car***

Project 6: ***The catapult***

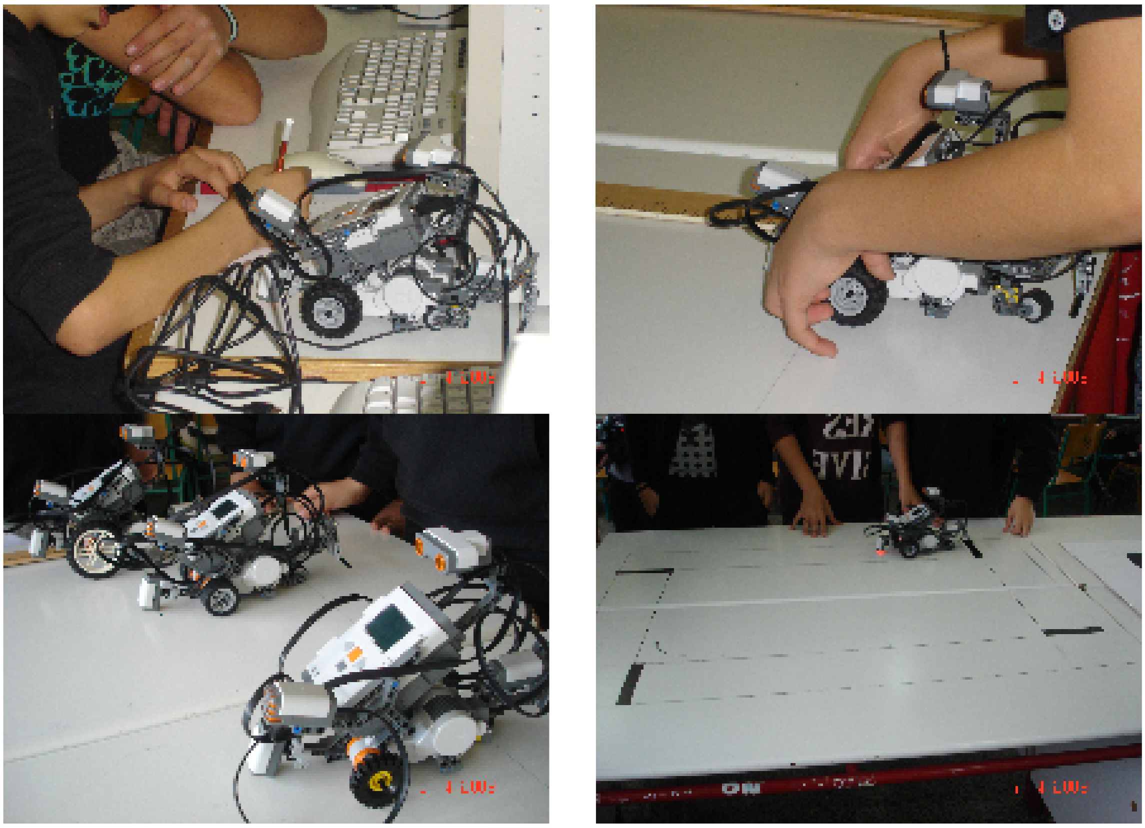
3rd challenge: Implementing educational robotics in the classroom

Our review of Research literature in Greece, Italy, Spain, France, Romania, Czech Republic showed a small number of implementations in real classroom environment of ER technology in primary and secondary schools. The main problems identified by the teachers during the evaluation of the pilot course in Athens, in implementing robotic-enhanced projects in school environment are: the lack of the appropriate hardware, the deficit in projects suitable for a specific group of students, the lack of teaching experience in working with group of students at a laboratory environment.

Teachers participating in the TERECoP training course were encouraged to implement robotic projects in their classrooms and were provided with hard- and software. Finally seven of them were involved in robotics-enhanced projects.

Projects within the school time table were implemented in 3 cases: the first one was in a primary school (2nd Dimotiko of Geraka) second one in a gymnasium (3rd Gymnasium of Glyfada) and the third one in EPAL of Korydallos. In each school trained teachers and teachers of the school interested in taking part in the project worked together with a TERECoP trainer to design a project according to students' and teachers' needs (taking into account teaching objectives and students learning profile).

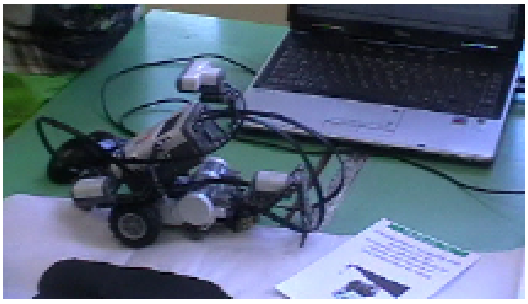
The lesson learned from this experience, is that it is important to support teachers to develop their own activities in their classrooms. Support should include methodological issues for developing activities, examples of good practices and communities of practitioners (involving also researchers if possible) that may support each other with their experience and support in the classroom during the implementation and evaluation of the activities.



The project: a moving vehicle (3rd Gymnasium of Glyfada)

Finally, other initiatives undertaken by trainees of the Hellenic course include extra curriculum activities on robotics-enhanced projects and participation to the first National Robotic competition.

The project 'Robopoly': Construction



working with the cards

The project "The little Karetta-Karetta

turtle and the old Volkswagen"

Projects developed at the 2^{nd} Dimotiko of Pallini

Introduction of educational robotics in primary and secondary education: reflections on practice and theory

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Introduction

In this work we reflect on our experiences from using Lego Mindstorms robots, for teaching basic concepts of programming in primary and secondary school. These emerge both from teaching in the classroom and participating in a robotics national competition. Furthermore, we try to highlight significant links of educational robotics to learning theories and identify major research issues for further exploration.

Background

The educational robots of the Lego Mindstorms type (in the following "LM robots") have been systematically used for the introduction of novice students to programming ([1], [2], [3], [4]), in the context of constructivist learning activities. Relevant studies, however, do not converge as regards any specific benefits emerging from this alternative method for learning programming. Nevertheless, many of them report that using robots has proven very helpful ([5], [1]).

In our effort the main objective was to investigate the degree to which the use of LM robots can: a) reinforce the interest of students to be creatively, pleasantly and effectively occupied with programming, and, b) help them transfer their programming knowledge from the context of robotics to formal programming environments (e.g. Visual Basic).

Research Method

In our research, which lasted two years, we involved two groups of students each year, one from primary and one from higher secondary education (first year: 6 students from primary and 12 from secondary; second year: 15 students from primary and 12 from higher secondary). In both cases (primary and secondary), students formed teams of three and the robotics lessons were organized in a format of in-classroom competition (student teams were learning how to program the robots in order to win in a final challenge competing against each other). The students were also motivated by their forthcoming participation in the first Greek national robotics competition which was also offering them the opportunity to take part in the world championship of robotics. Worth mentioning is that because of the great interest expressed by the elementary students for participating in the educational robotics lessons, questionnaires were used as a "filter" to select the participating students.

A qualitative type research methodology was applied in our study, as follows: during the implementation of our didactic approach we created activity logs recording students' comments and observations as well as our personal ones. What the students were thinking as well as their reflections on their experiences was recorded through semi-structured interviews.

Results

After collecting and grouping the research data, the following conclusions were recorded as major results:

- The engagement of students with LM robots contributed to their familiarization with structured programming principles, something that had a positive influence on developing problem solving skills. We observed that students understood more easily programming concepts (e.g. counter, flag, loop structure, etc.) which they had difficulties to realize and apply during the typical computer programming courses (learning programming languages such as Pascal, Visual Basic). A characteristic student's statement: "…I understand better a loop structure when it is to make the robot hit an obstacle three times and then stop. In this way it becomes interesting... "
- Using robots, the programming concepts acquire meaning for the students due to the direct and comprehensible feedback they get when implementing an algorithm.

- During the programming lessons it was noted that when learning new concepts, students related them to the relevant activities with the robots and this helped them to better and easier understanding programming commands (such as the control and loop concept). A characteristic student statement: "I never thought Visual Basic could be so interesting. Could we use it to program the Lego robots?"
- From students' comments it became obvious that in-classroom competition offered a strong motivation which kept the interest of the students undiminished and helped surpass any difficulties. Additionally, it greatly increased the desire of the students for engagement with programming.
- During in-classroom competition, the children demonstrated a tendency to outdo the opponent, more specifically tried to think of ways to sabotage the operation of the robot of the competitive team. A characteristic question by student: "…could we send a erroneous command to the other team's robot?" In that case, the role of the trainer was very important because not only the knowledge of how to intervene on the other robot's operation should be given to the students but, at the same time, the importance of fair play should be emphasized, cultivating this spirit among them.
- Students were highly motivated by the in-classroom competition and participated more effectively in both the constructive and programming part, having in mind the challenging goal. This became obvious by their strong desire to invest more of their personal time in order to participate in more learning sessions.
- During the lessons, a possible malfunction of the robots sensors or programming software had a frustrating impact on students. Nevertheless, the motive of participating in a robotics competition was strong enough to make these difficulties appear as trivial.
- The student teams that participated in robotics lessons cultivated a spirit of fair play, cooperative team work and strong friendship relations among students and their educators.
- The gaming aspect which is inherent in activities with programmable robots prompted children to be more creative, facing robot programming as an entertaining and easy occupation. The children's enthusiasm was obvious in their comments: "Why don't we use them at lessons?", "I would like to have one at home. How can I buy it?", "Can we play with the robots afterwards?"

Connecting to Learning Theories

Overall, we see that the robot-based activity is strongly connected to learning theories such as: game-based learning, motivation theories, and collaborative learning theories. An important conclusion from our experiences so far with LM robots is that the game and competition-based character of the learning activity strongly motivates young students in trying to acquire robot programming skills and, consequently, learn programming concepts and structures. However, another important aspect is that without teacher guidance and support students may easily get astray and not benefit from the experience.

Therefore, what we suggest is that using robots for learning should always be implemented in the context of appropriate collaboration scripts [6] (i.e. scripted collaboration), which assign roles to students, guide their interactions and help them accomplish specific learning objectives through the engaging experience.

Further Research Questions

We identify at least three critical questions within the educational robotics domain. First, the "knowledge transfer" question: Should we support students to transfer to formal programming environments the programming knowledge they develop while "playing" with robots? Is this a justified objective or should we be contented with allowing students simply to "enjoy" the robotics experience?

Second, the "metacognitive knowledge" question. What are the metacognitive benefits that the students reap when engaged in this type of activities? Can we somehow "measure" this type of learning? Does it contribute to students' increased achievement in other domains? How could we maximize the metacognitive benefits of students?

Finally, the "flexibility" issue. If we apply collaboration scripts how can we flexibly structure the activity, without, however, minimizing the joy and playfulness of the activity? What type of scripts and student roles would be appropriate for getting the most out of the learning activity? And, how should we adapt the level of support depending on students' experience and background?

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Support of computer science learning process through the use of educational robotics

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Robots, robotic constructions and robotic technologies have an intellectual and emotional appeal that exceeds any other type of engineered or educational product. This appeal is extremely intense for children and young adults. Robotic technologies represent a practical and handy application of physics, computer science, ICT, engineering, and mathematics. Moreover, robotics appeals to a broad range of scientific interests and allows multiple points of access to different disciplines for almost all types of learners. Interdisciplinary effort is of crucial importance for the integrated teaching and learning of computer science (CS) and Information and Communication Technology (ICT) concepts and techniques. An interdisciplinary framework can increase students' motivation and, thus, augment learning so that they become effective and more efficient in their personal, civic, and professional lives. Flexible and integrated thinking is what it takes to become successful in any real life demeaning situation. Interdisciplinary work and effort repeatedly draw on a real world context because real life issues and problems don't limit themselves to knowledge from just one subject domain. Interdisciplinary work can help young learners see the crucial connections between different bodies of knowledge, and more easily synthesize different and distinct domains. Real CS and ICT problems that draw on multiple forms of expertise facilitate students to see the complex relationship between subject knowledge and systems environment. Educational robotics draws from multiple scientific domains, belongs to "Interdisciplinary efforts" and supports students to better understand complex interactions and forms of expertise.

Nowadays robotic technology is being used by a large and steadily increasing number of educators:

a) to develop problem solving skills
b) to promote cooperative learning
c) to promote math and science careers
d) to reinforce computer science and ICT
e) to teach computer programming (variables, loops, conditions, counters)
f) to teach data collection techniques to use with sensors
g) to teach engineering concepts
h) to teach scientific and mathematic principles through experimentation

Some education professionals are predicting that robotics will soon be taught across all educational levels as a subject unto itself or as an educational enabler for other subjects. All educational activities in our school are scenario oriented and are based on the Sense Plan Act (SPA) framework. Top down design and problem decomposition are used for advanced programming activities in Lykeio and International Baccalaureate. To that end educational robotics is being used in our School across al school levels:

Primary school

Second grade pilot project

A pilot project that uses Lego WEDO programmable robotics kit and focuses on teaching and learning basic ICT skills is currently deployed in primary school. The project enables students to:

- Brainstorm various ideas and reach various solutions
- Develop various tests by changing one factor and observing or measuring the outcome
- Display and communicate data using tables and graphs
- Establish links and understand the relation and correlation between cause and effect
- Follow 2D drawings to build a 3D working robot
- Make systematic observations and measurements
- Think innovatively to make a new working model
- Think logically and develop a working program to produce a specific behavior

Robotics Club (fifth grade)

This club enables students that have curiosity about new technologies to build and program various robotic constructions. Students that participate in this club use LEGO NXT hardware and software to develop their own robotic constructions. Some of the students participate in various robotic competitions.

Middle school

Third Grade

In some occasions the LEGO NXT platform is being used together with the StarLogo TNG to boost programming skills. Students use in parallel both graphical programming environments to understand simple programming concepts and techniques.

High school /International Baccalaureate (IB)

Robotics Club

This club enables senior students to integrate their various skills to develop advanced robotic constructions. Parallax HexCrawler robot kit and Lego Mindstorms NXT robot kit are used in order to explore advanced programming concepts and techniques. Most of the students study CS in the IB program and are familiar with advanced programming. Some of the students select robotics as their area of interest for their extended essays thesis. Selected students participate in various robotic competitions and events.

Our School is equipped with three different robot types suitable to cover various educational needs.

Parallax HexCrawler Robot Kit is a programmable robotics kit that comes with programming software called Basic Stamp. The HexCrawler Robot Kit is equipped with the Board of Education programming board suitable for training, education and research activities. Students are able to use various sensors, assemble, program and analyze the infraction of the robot with its environment.

Lego Mindstorms NXT is a programmable robotics kit that comes with programming software. There are many different programming interfaces that students could use. The NXT software interface is adequate for basic and intermediate robot programming, such as driving motors, incorporating sensor inputs, doing calculations, and learning simplified programming structures and flow control. NXT software can transfer data via Bluetooth or included USB cable. NXT software provides an easy to use, drag and drop, graphical environment suitable for all ages. The graphics include data wires that show data flow from block to block (systematic).

Lego WEDO is a programmable robotics kit that comes with programming software. The material is designed for students in elementary school and enables students to work as young scientists, engineers and mathematicians providing them with the settings, tools and tasks for completing crosscurricular and interdisciplinary projects. Young students can learn by building and programming various models and by investigating, writing about, and discussing ideas they encounter using the models in these activities.

Psychico College focuses on targeted dissemination actions and initiatives. Two successful seminars (2008, 2009) were organized by the faculty of the ICT Department in collaboration with the Ministry appointed ICT Advisor, titled "Innovative Approaches to the Teaching of Computer Science and ICT". During these seminars innovative approaches such as educational robotics that have been successfully implemented in the teaching of Computer Science were disseminated. These initiatives gave the opportunity to other schools to benefit from the gained knowledge and expertise.

Robo-poly (Robo-city). An example of ICT enhanced teaching and learning through the implementation of robotic systems in Primary School

S. Terzidis, G. Goumenakis, E. Spyratou

2nd Dimotiko of Pallini

Introduction

Robotics in education finds its source in the teaching of LOGO as a programming language (Tsovolas & Komis 2008), which developed according to the principle of use by students in a context of learning and collaborative problem-solving activities. The whole approach relates to the teaching of constructivism in which students manage and construct objects using the language of programming as a tool for thinking and problem-solving (Papert, 1980).

In one of its first forms, the LOGO language was incorporated into a "tortoise", a robotic construction, which students moved by sending commands through a controller attached to it or through a computer wired to it. The robotic tortoise could leave a trail when moving and possessed touch sensors. From the 80s to the present, LOGO continued to develop, mainly as a programming language with emphasis on the tortoise's graphics, taking form lately as SCRATCH (http://scratch.mit.edu). The robotic version was only revived relatively recently, and with it interest in its educational value.

While LOGO, in its recent forms, constitutes a programming environment in which there is inter-reaction between student or student groups, computer and teacher, robotics constitutes a more complex environment. On a technological level there is the construction and the computer. The robotic construction must be assembled to take a variety of forms according to the task in hand. It is equipped with sensors which collect data from the environment and which can alter the behaviour of the construction. The computer is used for programming and determining the behaviour of the construction. Where class management is concerned, the usual practice is for students to work in groups and cooperate in their execution of the learning task, while the teacher assists the students by providing the necessary information at the beginning of the activity and organizing the experience at each stage of the project.

A Proposal For Robotic-Enhanced Teaching

"Robo-poly" constitutes a proposal for ICT enhanced teaching and learning with a robotic device in Primary school. It offers an exceptional method for introducing Primary school children to programming, given that they have no prior knowledge of programming or experience of programming environments. It includes a series of teacher-learner activities which aim to familiarize the student 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 proposal was implemented in a year 4 (D2) class of the 2nd Primary School of Pallini

The method used included the following stages:

- Familiarisation (or beginning): (to introduce basic concepts)
- Experimenting: the Robo-poly game (to acquire basic skills)
- Creating : helping the baby turtle to reach the sea (activities involving expression and composition)

In the familiarization stage, students were involved in introductory activities related to:

- **Discussion about what a robot is**: Students first completed a questionnaire then expressed opinions about and generally discussed what a robot is.
- **Assembly of the robotic device:** A considerably demanding (and time-consuming) activity, particularly if started from scratch. Students, however, completed the task in groups (each group assembling its own device) guided by both the teacher and instruction sheets while also drawing on their own previous experience with building blocks.
- **Presentation to the students by the teacher of the basic movement and control commands**: As students did not possess prior knowledge of robotic devices and related programming, it was necessary (within the available restricted time) to adequately familiarize

them with the various basic commands towards the turtle, of movement (forwards, backwards, left turn, right turn) and of those related to the sensor. They also needed to understand how the commands were written on the computer and then conveyed to the device, as well as how the various motors and sensors communicated and received commands from the device's processor. As the aim in this particular case was not to teach programming as such but to use a ready device and a very basic understanding of a programming language in order to develop a particular behaviour in a robotic device, only minimum information was given to the students regarding the robot's sensors and movement. Therefore, in this phase where presentation of essential information related to computer programming commands and different procedures involved in using the device by the students was concerned, an exponential approach was used.

In the play-experimentation stage students were introduced to the basic concepts of programming in a playful manner. They learned by playing the game Robo-poly (as reminiscent of " Monopoly"). The game was made up of 20 plasticized coloured cards (a teaching aid prepared by the teacher) with commands on both sides. On one side of each card commands organized into three levels of difficulty were given in words (eg. move the robot forward for 5 seconds, make the robot move ahead then stop with the sound sensor etc.) The first group had cards with the appropriate code corresponding to the lexical command in an optical programming language on the back, worth 10 points. The second group, whose tasks were an extension of those performed by group 1, had cards that were blank on the reverse, worth 20 points. The third group had complex tasks that were essentially a combination of commands from at least two cards in the first and second groups, and were worth 40 points.

Fig. 1. Card showing instructions to move forward for 5 seconds.

Robo-poly cards have the following advantages:

- Students can hold and refer to them.
- Students can place them appropriately to produce a sort of pseudo-code, being thus assisted in developing a programme of their own.
- They are part of an informal learning context which is a board game, ie. Robo-poly or Robo-snakes and ladders, which , as an organized game, accelerates the learning process.
- Where students are young, one is forced to explore alternative approaches with an element of play in order to achieve the original aims of robotic- enhanced learning. ICT implementation is prescribed by the curriculum and, given the restrictions of the traditional timetable, able to be included in the "Versatile learning zone'.

The students were divided into 4 mixed-sex teams of 4 children each and there was also one 5-member all girl team. The cards were separated into three groups according to difficulty, and the object of the game was for each team to gather 100 points. The object could be achieved by using a variety of different card combinations. The participating teachers supported the students and, when absolutely necessary, set up scaffolding to help children to discover solutions. When a team had trouble understanding the concept of a turn it was necessary for the teachers to dramatise the movement and illustrate how one wheel needs to move faster than another in order to execute a turn. At the end of each activity the students presented the task as a whole to the rest of the class, and each session was followed by a discussion related to teaching aims, difficulties that had arisen and the manner in which they were overcome.

Creating: Helping the baby turtle to reach the sea (expression and composition). The project in the final creative stage involved integrating literacy and the recently acquired robotic skills. The students were invited to solve the problem: How can I help the baby Karetta-Karetta sea turtle get to the sea? by likening the robotic device to a turtle. The stage involved:

- Presentation and discussion of "The little Karetta-Karetta turtle and the old Volkswagen", by Christos Bouloti, during Greek language class with student inter-reactions.
- Creation of a large classroom poster based on the symbolic elements of the text which mark out the baby turtle's possible route to the sea.
- Team discussion of the problem. Positioning of the poster in the classroom. Identification of the baby turtle's route to the sea. Alternative suggestions for a solution to the problem
- Planning and solving the problem: How to help the baby turtle to get to the sea.
- Reconsideration of facts learnt and skills acquired earlier. Each team planned, described, experimented and solved the problem in its own way by programming the robot accordingly
- Presentation of each team's solution to the other teams: Will the baby turtle actually reach the sea?
- Evaluation and discussion of each team's achievements by the whole class.

Discussion

When the teacher presents a new item to his or her students, he or she accordingly "takes on" various roles. For example, he initially provides information, then later encourages inter-reaction among students with the use of teamwork and student-centred procedures.

The activities that students become involved in (the familiarization and experimental stages) are related to their abilities and aim to (gradually and playfully) help them build the necessary mental framework to then practice programming activities (in the creative stage).

A number of differences were observed between the groups throughout the implementation of the proposal. Students who had experienced Lego constructions before built the robotic device very quickly and then either helped others who had difficulties or experimented with the commands on the device. As the teaching proposal progressed it was observed that different students in turn took on a leadership role within their groups and the problem-solving evolved in a pleasant and constructive atmosphere. In many cases, when aims had not been achieved, the teaching procedure had to be extended. The teachers were obliged to find alternative questioning forms to those ordinarily used in the classroom to elicit correct answers, with questions focusing on content and methods for discovering the correct answer.

At the end of the school year, in June 2009, the entire class referred to their robotics experience as if not the best, one of the two most favoured activities.

Acknowledgements

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Experiences from WRO 2009 competition and verifications about the robotics incorporation in the school

N. Giannakopoulos

3rd General Lyceum of Patras

Abstract. This paper describes the experiences from the 3rd General Lyceum of Patra's participation in the 1rst national robotic competition WRO 2009. It also presents the main verifications from various activities that have been elaborated using LegoMinstorms to prepare the participants for the competition. Through the recording of these experiences and also from previous school participations in various robotics projects we have a series of verifications about the robotics incorporation in the classroom. These verifications probably could be useful to somebody who would like to make a proposal about the way robotics could incorporate in to the school curriculum, and especially in the High School as a typical lesson in the curriculum. At the end an example of a robotic scenario activity is presented, which has been inspired from computers programming elements that students are been taught according to the high school informatics lessons

Introduction

In the past years many students from different Greek Schools have become accustomed with robotic subjects through many kinds of projects. Some Programs like "Technomathia" or the program "Dedalos" have given the Teachers-researchers and students teams the opportunity to approach the robotic subject through a project. In addition many Creeks schools, public and mainly private ones have created a robotic laboratory using (Mindstorms® NXT® Kit) as an ideal "packet" for educational robotics that is appropriate for all stages of education, from primary school to university. Through the European project «Teacher Education on Robotics-Enhanced Constructivist Pedagogical Methods» (TERECoP), ASPETE tried one more formal and more organized to incorporate robotics in to the school curriculum.

Recently the 1rst National robotic competition WRO 2009 involved 13 teams from primary schools, 11teams from secondary schools and 17 teams from high schools. This participation shows the growing interesting for the robotic in these stages of education. This growing interest from both teachers and students increases the possibility of incorporating robotics in to the school curriculum as a subject.

The WRO 2009 competition

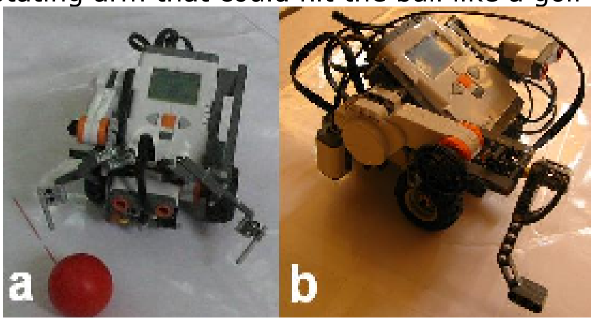
The case of the 3rd General Lyceum of Patras participation in WRO 2009 competition was the cause to involve the students for the first time with LegoMindstorm.

The first stage was the construction of a court for the regular category (Robot Pocket ball – High school) and the start of the team's training.

The second stage involved the construction of a very simple robot with two independent moving wheels and one helping wheel for programming test and for navigation in the court. This first robot didn't have any kind of tool to catch the balls that were placed in to the court.

The third stage followed the construction of the tool for the balls.

After a small search on the Net for ideas we had two proposals for the tool construction. The one proposal from coach introduced a gripper that could catch the ball (image a) and the other proposal from a student introduced a rotating arm that could hit the ball like a golf club (image b)



Finally we realized both these two constructions because the team had bought 2 packets of Lego Mindstorms. For each construction we had a different programming scenario because the appropriate position that the robot had to take towards the balls was changed.

Students worked on both of these scenarios simultaneously trying to discover which were of them the best. It is worth noticing that after the first tests, they gave up the idea of crossing the robot through the uneven area (ping-pong balls) because they had to use a caterpillar which they didn’t have. At this point we must highlight the usefulness of the Lego Mindstorm pack and the supportive help that was offered to the students in a way that allowed them to process and discover the packet alone without the teacher’s support.

On the construction level the instructions that were offered from the help menu including all the separate steps, were very helpful and made the students construct their first robot easily. In addition the software interface was very friendly and easy to use. Very interesting were the first’s activities that students performed using the sensors. Many of the students had already learned theoretically about microcontrollers and sensors. Although it was the first time they saw something like this in real action, they had the opportunity to create the program alone and specify their own parameters. Simple activities like making the robot stop on the black line or making the robot take a parallel position along the black line, or making the robot stop at a specific distance from the wall were the first exciting experiments that the students performed with enthusiasm. Working on navigation level within the court, students had to use theoretical background like Mathematics Trigonometry to map with accuracy the robot’s route. This point was very interesting from an educational view because a change was noticed in the students attitude towards handling theoretical issues like mathematical formulas and scientific rules.

At the end of the competition the team had uploaded a relevant video including scenes from the preparation and from the event on YouTube site on the following link: http://www.youtube.com/watch?v=IelmDqPorbY&feature=channel_page.

The main points that could ascertain through this task and procedure were:

1. Students are very interest in new technologies.
2. Technological achievements like robotic vehicles excite student’s interest and they constitute a strong motivation for learning.
3. Through their effort to improve their vehicle’s abilities they don’t hesitate to get involved in matters with enthusiasm that in other cases would be boring and indifferent to them. For example the pursuit of a mathematical formula to calculate an angle or a distance suddenly became an extremely interesting subject.
4. Students are strong motivated with the idea of a competition with other teams. Robotics teams and robotics tasks for them are very similar to sports such football or basketball.
5. The robotics courts and the competition rules are very close to their favorite sports, which they adore.
6. The vast majority of students are interested in robotics because unlike traditional sports, in robotics all the students have the opportunity to be winners (not only the physically strong students with athletic skills but also the others that can propose a practical construction or a smart solution or an effective robotic game)
7. Their involvement in theoretical issues like mathematical formulas and physics equations becomes a vital matter for the achievement of their purpose

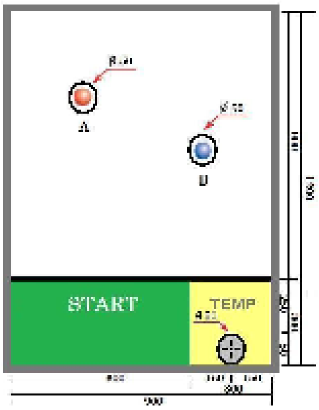
8. Students can see for themselves the usefulness and the power of algorithm and programming languages through real applications.

Designing a robotic activity: "The Swap activity"

One issue that students were asked to respond to the National examinations 2009 in informatics was the swap procedure.

From my personal experience as an examine marker I realized many types of misunderstandings of this topic even from very good students. This was my reason to create the "Swap robotic activity" according to the motif of WRO2009 competition's task. Simultaneously, I try to make clear to the students how exactly the swap between two variables takes place

Here is the court for this activity:



NOTES: All dimensions in the court are measured in mm. A, and B positions are RANDOM but they must always be located on the white area. The minimum distance between A and B must be 250mm. Competitors are not supposed know these positions in advance.

RULES: TEMP position is known and it is located at a specific point (at the bottom middle yellow area) as it is presented in the court. Balls are common pong balls (diameter 20mm) in red and blue color. For positions A, B and TEMP it would be perfect if we used empty refreshment cans 150ml (diameter 50mm and high 90mm) on top of which we can put the balls.

AIM: The Robot must start from anywhere within the green area. Then it must swap the red and blue balls which are located in A and B positions, using the robot gripper and the TEMP position. It is not allowed to leave any ball in any other point on to the floor except for the positions A, B and Temp. After robot has achieved the above task, must turn back to the START position. Winner is the person who ends the task at the shortest time.

Discussion and conclusions

Taking into consideration the above findings for the introduction of robotics in high school education we could say that we need to design a curriculum of robotics that could involve the students in activities that can apply to theory and knowledge from Maths, informatics and Physics. So robotics lessons would be able to work like support in these traditional lessons or like an elective lesson such us Multimedia – Networks or Computers applications. The similarity of robotics with informatics and its use in the field of real algorithms application renders robotics a very useful tool that could be used for understanding various other lessons.

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Development Of Learning Strategies Focusing On The Construction Of Mathematical Meanings Using Contemporary New Technologies And Innovations Of Tangible Materials

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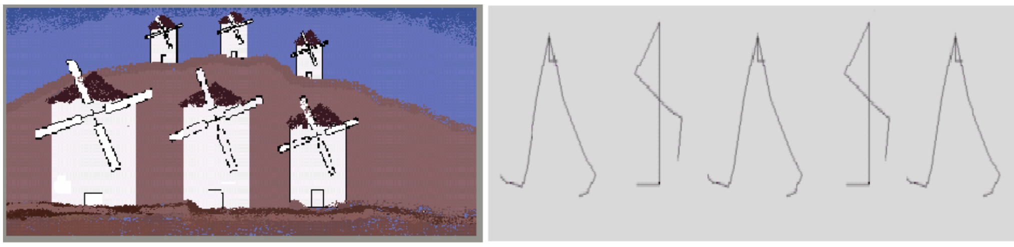
Evageliki School of Smyrni

During the academic year 2008-2009, within the scope of the cultural aspect of the curriculum, we developed teaching instructive practices aiming at observing the development of the systemic approach of importing software as well as tangible material in the teaching procedure of mathematics; inside the frame of the curriculum; and investigating the problems which arise from this adoption and answering questions concerning the way students cope with the new practices in maths teaching.

In this project participated all the 1st grade students of Junior High school (three groups – 90 students in total) as well as their maths and IT teachers. However, during the action we focused on 6 students who we could observe not only in class but also while they were working on robotics in a smaller team.

The method of observing and analyzing the learning procedure was the 'teaching experiment' during which we caused certain events so as to check situations? To begin with, we decided to involve students asking them to design activities using programs of symbolic expression and dynamic geometry so that they could easily understand the objective of activity and use mathematical significances which either were acquaintances from pre-existing knowledge, or existed in the syllabus of the 1st grade maths or were significances that were elected by the particularity of the tool or by the requirements of the activity. At this kind of tasks maths were underlying did not aim primarily at the teaching of mathematics. Students had a clear focus and could immediately act in construction, being offered a wide choice. We chose the topics of 'bulding a windmill' and 'human walking'.



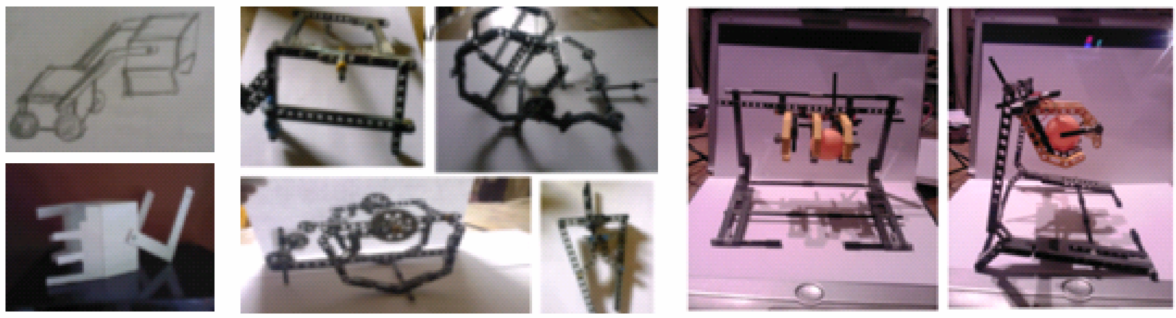
Sample representations of constructions on the themes of 'bulding a windmill' and 'human walking'

Our next step was to make students visualize a variety of mathematical significances using the techniques that they had applied in the previous tasks and, thus, guide them from the abstract to concrete concepts. Finally, we aimed at making the students use these techniques to create their own constructions.

We mainly used MicroWords Pro and the group of 6 students also used NXTedu. Once a week in the computer laboratory students worked in groups of three and took turns at the specific roles. Our original plan was to move from the MicroWords Pro environment to the Robotics environment using a robot toirtoise. Our intention was to get all the students involved in the design, the construction, the programming and the experimentation (learning through constructing / constructionism, Kafai & Rescink etc 1996) instead of resorting to the teacher lecture of robotics. However, we faced the following problems and difficulties:

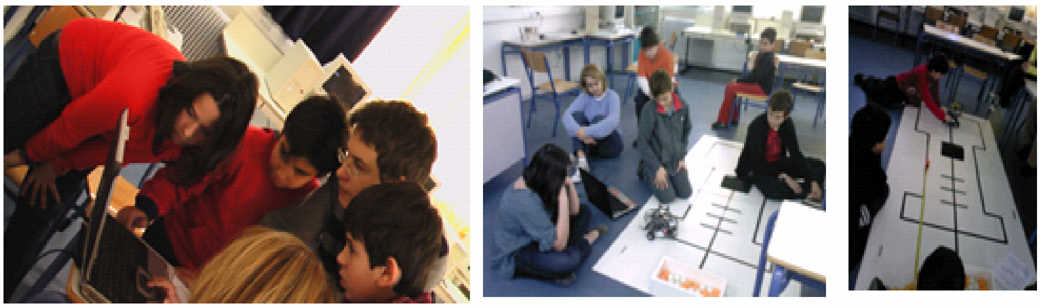
Within the curriculum, our students did not have the time needed to design, experiment with, program and try their models. We lacked time even when we were at the initial stage and, as a result, we could not reach our aims. Due to the large number of students in class, there was not enough room for all 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 to meet due to their busy afternoon schedule. It was necessary to make obvious to the members of the school community the importance of teaching robotics so that the school would finance the purchase of the robot. We finally decided to form a group of 6 students who would work on robotics and eventually take part in the robotics competition. However, we decided to abandon the activities which had to do with the robot tortoise. We strongly believe that the competition motivated our students and stimulated their interest. Although our students lacked the time and knowledge necessary for the completion of the project, they took part in the competition so that we could observe them working in a small group, towards a specific aim and then compare their work and involvement with the more general of the first project. We tried to monitor the students of the team when we considered it appropriate but generally we encouraged them to take initiatives in their roles and become an independent team.

Initially, they constructed a simple model (a vehicle) following specific guidelines and they experimented with its programming so as to understand how it worked. Then, they constructed the court where the vehicle should move according to the terms of the competition on a scale of 1 to 1.

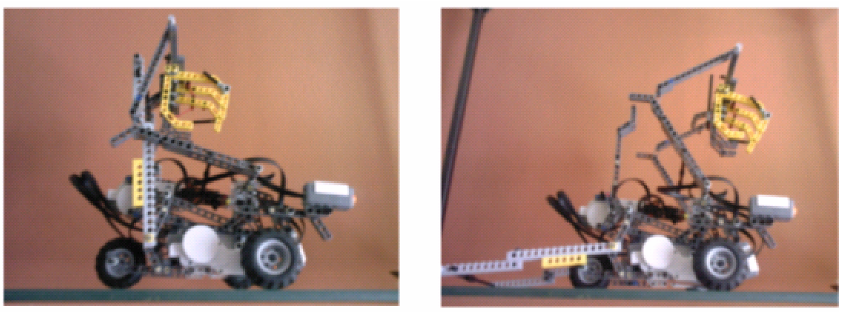


Illustrations of different stages of the construction process

The team studied the construction requirements of the robot taking into account what it should be able to do and they analyzed it in individual stages. For the concretisation of each stage, the members of the team discussed, designed, constructed, programmed, experimented and made the necessary changes.



Illustrations   of group work



The final construction that took part in the robotics competition

General comments

During the general activities, all six students were able to cope with our instructions following the rhythm of the class. They waited for the next question or task in order to respond and take action. As members of the robotics team, however, not only were they able to use our initial guidelines effectively but also they took initiative so as to adapt to the new environment and explore it.

At the general activities we were aware of the pivot on which the tasks developed. While working with the robotics team, the problem that had to manage had not been answered by us; we had to find answers to the problems we dealt with and this had as consequence the closer communication between students and teachers We consider that this direct interaction between the two sides and the way it developed played a major role in the way the students worked and learnt.

There were cases when instead of actively participate in the actions that corresponds in their role they used the construction elements of NXT to play and produce simple small artifacts which they showed to each other. We allowed such activities but we also tried to understand what they were doing and tried to connect their work to the main action of the team.

While designing, constructing, programming and experimenting, the students used ad hoc practices. This gave us the opportunity to pinpoint relevant areas in mathematics, physics and information technology which were part of the curriculum. In this way, students approached formal concepts while constructing.

Their parents' attitude towards the whole project was positive and supportive, which helped the team. However, we did not have the same result in the general activities at the first part of our program.

Using LEGO Mindstorms in Technical and Vocational Secondary Education (the transmission of rotational motion: a case study)

G. Vounatsos

1st EPAL Zografou

Theoretical Framework

Robotic technology into the instructive practice focuses at the ''constructional'' use (Alimisis 2008) of educational technology (constructionism) as a tool of constructive learning (Papert 1991). The constructive theory of learning supports that one of the basic conditions for the conquest of knowledge is to import students in authentic educational situations and activities that will have realistic content, inspired from the experience of the daily life.

The use of calculating tools and control technologies, as tools of thought, contributes in knowledge building individually and socially, while at the same time students develop their post-cognitive conscience. The traditional approach in the Greek technical and vocational education recommends that the students watch a laboratorial course only after they have been taught the relative theory. On the contrary the constructive approach and particularly the discovery learning theory claims that the students are more likely to comprehend and recall notions and meanings which are discovered at the duration of their personal search. In this direction the robotics, and LEGO Mindstorms technology can be proved exceptionally useful (Moundridou & Kalinoglou 2008).

Methodology

The research followed a project-based methodological approach. The relevant bibliography (Kynigos and Fragou, 2000, Alimisis 2005, Moundridou & Kalinoglou 2008) shows that project-based researches provide high motivation in students while simultaneously lead to deeper conceptual comprehension.

During the research we worked with two (2) pilot groups, constituted by three (3) students of the second grade of Mechanical Sector (16 to 17 years old). The sample choice was random and the representation of same sex (boys) students in the teams considered representative for departments of particular technical course.

The Study

In our research project we tried to point-out the contribution of educational robotic technology in the construction of scientific meanings of Mechanics and the discovery of rules and relations that sustain. Concretely we focused in the study of rotational motion transmission via belts, and basic relations that connect values that describe this phenomenon. The transmission of motion via belts constitutes a basic scientific field in technical and vocational education with a lot of practical implementations in everyday life (e.g. mechanisms of transmission on vehicles, fan-cooling systems in cars, mechanisms in generators etc.).

The interest of the inquiring subject is impressed in the relative bibliography (Alimisis et al, 2005, Moundridou & Kalinoglou, 2008, Chambers et al, 2008), which shows that students have often blurry or even erroneous aspect regarding the concept of motion transmission. The comprehension of transmission of motion is generally considered a tortuous subject for teenagers and adults (Papert 1980).

Construction of the Robot-Model-Vehicle

In this stage of the study the students begin the construction of a robotic vehicle. The model concerns a vehicle that will bring a motion transmission apparatus via pulleys and flexible contacts, simulating an belt-transmission-mechanism. The goal of this phase of the research project was the entanglement of students in a creative process that will outcome to a robotic entity with characteristics that they'll have selected on their own.

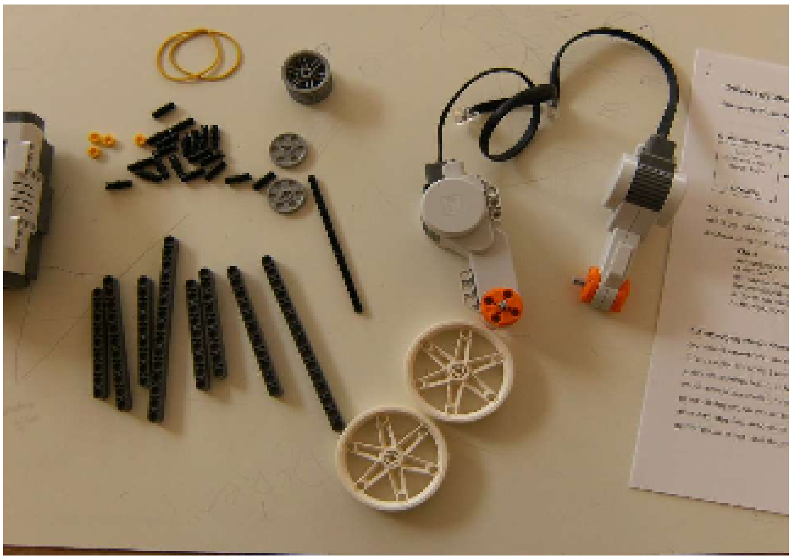


Figure 1: Structural materials

As showed in **Figure 2** below, the NXT processor (smart brick) placed on a frame manufactured from structural LEGO materials (**Figure 1)**, essential axes for the rotation of four wheels, sound sensor, a servomotor connected on one axis and an indicative operation lamp.

Figure 2: Vehicle 1

Calculating the car speed

At the speed calculating activity students record the dimensions of pulleys that are going to be used for the rotational motion transmission. There were four pair of pulleys, therefore enough possible combinations to differentiate the transmission ratio and influence the speed of vehicle. Then by controlling the command-icons (**Figure 3**), students alternate the programmed functions and change the behaviour of vehicle.

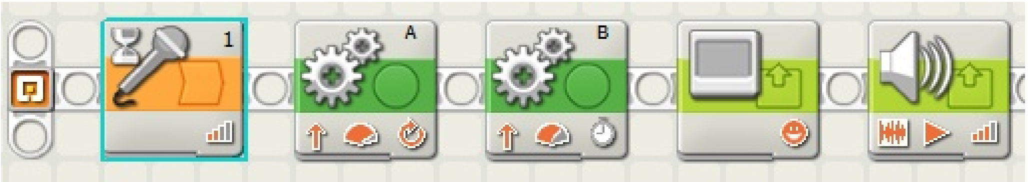


Figure 3: Commands - icons of the program

In **Figure 4** we can see an alternative construction of the robot-car made by the students. The vehicle was designed specifically to fulfil a range of constructional conditions and transport rotational motion via thills - pulleys - belts mechanisms.

Figure 4: Vehicle 2

Results of the study

The student questionnaires were drawn aiming to review the inquiring process and the verification of children's aspect on the instructive experience (evaluation of the research planning and the instructive approach). For this reason we draw in the questionnaire closed and open type fields , overall nine (9) closed type questions had six-grade asymmetrical answer scale (0=Not-at-all 5=Absolutely) while four (4) questions were open typed. Finally we left students the ability for general comments at the end of the questionnaire. The answers of the students who participated in the research are impressed in the table that follows (Table 1).

Question	**0**	**1**	**2**	**3**	**4**	**5**
Was the aim of your work evident?	-	-	-	-	66,67%	33,33%
Was the usability of the robot: satisfying?	-	-	-	-	33,33%	66,67%
Did the robot - vehicle served the aims of the course?	-	-	-	-	50%	50%
How interesting were the designing and construction of the robot?	-	-	-	-	-	100%

Were you satisfied with the interaction with the computer software?	-	-	-	-	33,33%	66,67%
After the experiment with the vehicle, can you recall the instructive object with which you've worked on?	-	-	-	16,66%	66,68%	16,66%
Was the learning approach of the topic easier with the use of program and the robot - vehicle?	-	-	-	16,66%	16,66%	66,68%
Did your collaboration with the schoolmates help you advance in the solution of arising problems?	-	16,6 6%	-	-	66,68%	16,66%
Would you recommend the particular process to your other schoolmates for experimentation?	Yes 100% No 0 %					

Table 1: Student's responses

It's rather easy to observe that the student's answers are assembled, mostly in the positive side of the scale with more usual prices from 4 (a lot) and above. Also the universal intention of the students to propose the particular experimental work in their schoolmates, shows that the general opinion about the educational process was very good. The same thing stands also for the designing and constructional part where the answers of students was at the biggest positive.

The teams and their members did not have gaps or misunderstandings about to the aim of their work, despite the playful type of the educational activity and LEGO materials, the objectives were explicit enough, and the experimental frame encouraged the emergence of concrete problems-to-be-solved and questions-to-be-answered.

Concluding Discussion

Through the process of building, programming and controlling mechanic models, as well as the study through experimentation, the students tried to implementate their ideas and work out prototype conclusions regarding the concept of motion transmission, the functions that describe these operation but also the natural values that influence the linear motion of the vehicle. Students used problem-analysis techniques, solution-planning, building their own model and intervening in the software that controls its behaviour, to achieve specific objectives. We allegate that in this way students intercoursed but also comprehended, certain basic concepts and meanings of motion transmission, as well as the form the related natural values. Students indeed reached in ''discovery'' of multiple proportional relations between constructional dimensions of the model and the observable rotational speed. Observing the course of students work we noted an increasing interest and devotion for the work. Students while initially encountered the project with suspicion, probably dew to its extraordinary and ''exotic'' texture, nevertheless they familiarized rapidly with LEGO materials and the computer software and they were actively involved in the synthetic project. At the end the project both student groups were able to intervene in the functional characteristics of their structured robot-vehicle, to use the LEGO Mindstorms Edu NXT software in order to make appropriate programs, and to evaluate the output data received as feedback from the system.

Finally students inventiveness and imagination are mobilized in the solution of practical problems, e.g. the suitable positioning of belts so that the essential strain (tensity) is achieved. Additionally, verbal expression of ideas and communication skills are cultivated through the team - work, when students get to explain their ideas and thoughts, as well as abstractive faculties through the interaction with the symbolic - virtual environment of the supporting software (LEGO Mindstorms Edu NXT). This case study provides positive clues that the construction and programming of robotics objects can include itself efficiently in a process of creation controlled models, that graphical programming techniques ''acquire meaning '' for the students, dew to the direct and observable connection of the software program with the behaviour of the model. It showed also that LEGO Mindstorms NXT robotics, within a suitable pedagogic framework, can contribute substantially in the teaching of Mechanics and Technology. These conclusions appear to agree with the results of other researches on similarly robotic systems (Moundridou & Kalinoglou 2008, Alimisis et al, 2005, Kynigos & Fragou, 2000).