Robotics in Education & Education in Robotics: Shifting Focus from Technology to Pedagogy

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***Abstract*—In this work we highlight the role of constructivist pedagogy and consequent educational methodologies either while using robotics in school education (*Robotics in Education*) or while training teachers to use robotics for teaching purposes (*Education in Robotics*). In this framework, constructivist methodologies for integrating robotics in school physics and informatics education and in professional teacher training are suggested. Exemplary projects from each case are reported to demonstrate the learning potential of the proposed educational methodologies involving teachers and students while using robotics to study kinematics and programming concepts in physics and informatics classes of secondary education respectively.**

***Index Terms*—Educational robotics, teacher training, informatics education, physics education**

I. Introduction: "There's Nothing so Practical as Good Theory"

Over the last few years, robotics in education has emerged as an interdisciplinary, project-based learning activity drawing mostly on Maths, Science and Technology and offering major new benefits to education at all levels [1], [2]. The use of robotics in education is aimed to enable students to control the behavior of a tangible model by means of a virtual environment. Very often these efforts are limited in just introducing robotics technology (following the axiom "the more advanced the better") in education and underestimate the role of pedagogy that should support any such attempt.

However, the successful introduction of an educational innovation, like robotics, is not just a matter of access to new technologies. As important as the technological advancements are in the development of robotics, the real fundamental issue from educational perspective is not the technology itself; it is the educational theory and the curriculum guiding the use of robotics in any educational context. The robot is just another tool, and it is the educational theory that will determine the learning impact coming from robotic applications.

Alignment with theories of learning, proper educational philosophy, well designed curricula and supportive learning environments are some of the important elements leading any educational innovation, including robotics, to success. Thus, the emphasis in this work is on shifting from technology towards partnership with education putting the emphasis on pedagogy than on technology and especially on pedagogical principles and methods coming from sound learning theories, such as constructivism and constructionism.

During 2006-09 the European educational project *TERECoP* (*Teacher Education in Robotics-enhanced Constructivist Pedagogical Methods*, www.terecop.eu) worked to this direction and developed a methodology for training teachers and for introducing robotics in school both as learning object and more importantly as learning tool [3], [4]. The TERECoP method was inspired from the educational philosophy of constructivism [5] and was mostly based on project-based learning. In the "after TERECoP era" we have continued working to implement the ideas of the project in collaboration with teachers and schools in formal and informal educational settings. Our efforts are focused on teacher training and on supporting teachers to implement robotic activities in school classrooms [4].

Following this framework, this paper presents in the next sections a methodology for introducing robotics both in teacher training and in school classes and two exemplary projects realized in two different contexts: in training courses for future teachers of technology and in further training for experienced in-service science teachers. The transformation of each training action into consequent learning activities in school classrooms is also exemplified. Finally, conclusions from these case studies and future plans are presented.

II. Introducing Robotics in Teacher Training and in School Classes

A. Methodology

Our methodology views robotic technologies not as mere tools, but rather as potential vehicles of new ways of thinking about teaching, learning and education at large. We appreciate much the importance of learners' pre-existing knowledge, conceptions and culture, as well as of their interests and varied learning styles. Our approach encourages learners to participate actively in the learning process.

Through robotics learners build something on their own, preferably a tangible object, that they can both touch and find meaningful. In robotics, learners are invited to work on experiments or problem-solving with selective use of available resources, according to their own interests, search and learning strategies. They seek solutions to real world problems, based on a technological framework meant to engage students' curiosity and initiate motivation [3].

The robotics industry so far mainly aims at humans using pre-programmed pre-fabricated robots. The ways in which the robots are made and programmed is a black box for their users [6]. It is a paradigm compatible with the traditional educational paradigm of the teacher or of the curriculum book revealing and explaining ready-made ratified and thus unquestioned information. Very differently from this approach, our methodology suggests the transition from "traditional" black-box technologies to the design of transparent (white-box) digital artifacts where users can construct and deconstruct objects and have a deep structural access to the artifacts themselves. The white-box metaphor for construction and programming might generate a lot of creative thinking and involvement in learners [7].

When students can have control of specific robots in a rich learning environment embedding the construction of robots and programs to control them, the emphasis might move on interesting learning activities in the frame of specific learning areas such as science and technology. The design of robotic construction activities is associated with the fulfillment of a project aimed at solving a problem. In such a learning environment, learning is driven by the problem to be solved. To engage students in activities requiring designing and manufacturing of real objects, i.e. robotic structures that make sense for themselves and those around them [5], we should devise activities that will encourage students to construct robots but also to encourage them (providing the necessary support) to experiment and explore ideas that govern their constructions.

The robotic activities may take the form of a research project posing problems that are authentic, multidimensional and can have more than one solution. It is particularly important that the problems are open and allow students to work with their own unique style and the way they prefer. The proposed work should actively involve students in learning opportunities by giving them control and ownership of their learning, encouraging creative problem solving and combining interdisciplinary concepts from different knowledge areas (science, mathematics, technology, etc.). The learning activities are as open as possible so that learners have opportunities to participate in the final configuration of them and ultimately provide opportunities for reflection and collaboration within the team.

B. The role of the students

When preparing a work with programmable robotic constructions, students first discuss the research problem through a free dialogue in their group and after that in the plenary session of the class and devise an action plan to solve it. Then, they work in groups to implement their plan taking into account the feedback they receive from the educator. Students experiment with simple programmable mechanical devices (e.g. a car-robot, motors, gears, pulleys, shafts, sensors, etc.) and associated software. Students may redefine the research plan after the experience gained during this preliminary work. They are invited to synthesize their findings and reach conclusions and solutions to the problem under investigation. The final products and solutions of the groups are presented in the class, are discussed and evaluated. Finally students are invited to reflect with critical mind on their work, to express their views and to record their experiences in the form of a diary.

C. The role of the teacher

The teacher in such a constructivist theoretical framework like that described above does not function as an intellectual "authority" that transfers ready knowledge to students but rather acts as an organizer, coordinator and facilitator of learning for students. S/he organizes the learning environment, raises the questions / problems to be solved, offers hardware and software necessary for students' work, discreetly helps where and when necessary, encourages students to work with creativity, imagination and independence and finally organizes the evaluation of the activity in collaboration with students.

III. First Case Study: Robotics in Informatics Education

A. Integrating robotics in training courses for future teachers of technical secondary education

In the framework of the one-year training programs held for future teachers of secondary technical education at the School of Pedagogical and Technological Education (Patras, Greece), starting from the academic year 2010-11 a robotics module has been integrated in the course of educational technology.

The robotics module starts with a short "theoretical" part that includes discussions about the theoretical background and the educational potential of robotics, suggestions on the potential use of robotics in school classes and presentation of the LegoMindstorms NXT package, of the programming environment Lego Mindstorms NXT Education software (http://www.legoeducation.us), and of the Lego Digital Designer (software simulating robotic construction and used to facilitate students during their first constructions, http://ldd.lego.com).

A laboratory part follows when students participate in a series of practical activities taking place in the Educational Technology Laboratory (Patras, Greece, www.etlab.eu). An illustrative scenario implemented in these activities follows:

a. Students are divided into groups of 3-4. Each group is allocated a Lego Mindstorms NXT kit and is invited to plan and discuss the construction of a vehicle. They are asked to design first with paper and pencil their artifact; they can also use Lego Digital Designer to design a virtual model of their robot if they wish; finally they build the mechanical vehicle using the Lego Mindstorms kit. Each team designates a representative to present their work to the plenary of the class.

An excerpt from the worksheet given to the students is quoted below:

Worksheet 1: Use your Lego Mindstorms kit to build a car.
The car should have ...
- A frame (chassis) like this in picture (Fig. 1)
- 4 wheels
- An engine that will actuate the two front wheels
- The "smart brick" Lego Mindstorms should give

instructions to the motor to rotate
Talk to your team and draw roughly the car here as you imagine to build it. You can use the model available from Lego Digital Designer for your construction if you wish…
Make now the car and be prepared to present it in the class…

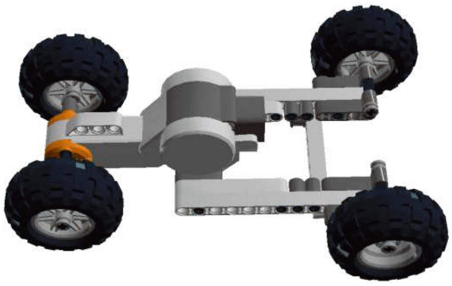

Fig. 1. Focus on simplicity: a purposely simple car proposed to student-teachers

b. Introduction to programming using the Lego Mindstorms Education NXT software.

The students practice with the basics of Lego Education NXT software starting with the Block "*move*"; they continue with the controller to load programs from the computer to the robot, the touch, light, sound and distance sensors, they learn to control the block "*wait*" and more. Students are free to experimenting with the software and the robotic vehicle they have already constructed. The trainer helps discretely the students when necessary without restricting their inventiveness and self motivation. Each group appoints a representative to show in front of the class the results of their work. The trainer comments and makes suggestions where appropriate.

c. The lab activities continue with specific problems involving control of motors and sensors, such as:

Take your car to move forward with the throttle (Power) at 70% for 1 second and brake, repeat for 2 seconds, then for 3 seconds and so on. What do you conclude from this experiment? How can you make the robot-car, as it moves, detect the obstacles that touch, stop and turn back? (excerpt from worksheet 2).

d. Design and implementation of a team project by the students.

The trainer invites students to design and realize their own scenario; they work in groups to realize their ideas by programming the robot-car; they are called to describe in their own words the solutions provided; each team designates a representative to present their work to the class; the trainer comments and makes recommendations where necessary.

Upon completion of this training, students are encouraged to transfer the robotics activities in classroom on topics of their choice. For this purpose we use the context of teaching internship and our partnership with local schools which accept our students to work as temporary teachers. A case study from such a classroom project is reported in the next section.

B. Teaching programming concepts in school informatics through robotics

This project was realized by two of our student-teachers specialized in informatics who had attended the robotics training course mentioned above (academic year 2010-11). Robotic vehicles built with Lego Mindstorms kits were introduced for 2 teaching sessions (2 hours for each session) in a lower secondary school class of informatics with 21 pupils aged 13 (April 2011, Patras, Greece) to support the learning of making decisions and loop control programming concepts. Robots (simple cars with four wheels, one motor and one ultrasonic sensor) should be appropriately programmed by the pupils to perform simple motions and actions which would involve the use of making decisions and loop behaviors in computer programs.

The student-teachers explained in the class using concrete examples just the basic building blocks of a program (move, wait, conditional wait, loop, switch etc.) along with the steps necessary to build a program and download it to the robot. After that, pupils were called to imagine a behavior for their robot involving decision making and/or repetition and then to describe it using paper and pencil before programming it to their robots in the second part of the activity. At the end, the groups were asked to present the behaviors they had thought of and to demonstrate them with their robots in front of the whole class. Most groups managed to program the intended behaviors after some trial and error attempts. The student-teachers acted rather as experienced advisors, encouraging the pupils towards the solutions but not doing the work for them. Finally, they evaluated their whole teaching intervention based on the analysis of pupils' work as it had been saved on the computers of the laboratory and on the analysis of pupils' diaries [8].

After the end of the project, the student-teachers' experiences were recorded through a written report and a non-structured oral interview. As the student-teachers reported [9], the feedback collected from the classroom had verified their initial assumption that a robotics activity would be appealing to the students and could help in bringing abstract programming concepts closer to the pupils' understanding. They appreciated the opportunity they had to explore the difficulties encountered by the pupils working out the new programming concepts, to understand how students preferred to work and finally to gain insights on how future educational activities should be planned and designed. The robotic activity had enabled student-teachers to see the results of their actions in the school class reality and to get immediate feedback from pupils, which as they reported had increased their self confidence in using robotics in school [9].

Evaluating this teaching intervention, we can first identify the obvious similarities between the methodology proposed in the training course and that applied by the student-teachers in the school class. We can claim that student-teachers successfully implemented the robotics-based methodology they had been taught, on a topic of their own choice and specialization in a real classroom setting. Second, this connection between training course and school class proved useful for them because they were provided valuable feedback from pupils' work which convinced them that the use of robotics according to the proposed methodology is realistic and feasible and finally strengthened their self confidence for future use of robotics in school.

IV. Second Case Study: Robotics in Science Education

A. Integrating robotics in further training for in-service science teachers

In the framework of further training courses for in-service physics teachers held at the University of Athens (September-December 2011), we introduced robotics in the curriculum of the course for 10 teaching hours for a group of 6 trainees; all of them had long in-service experience, high educational qualifications and after their training they would act as trainers of their colleagues in their schools. The main aim of the robotics curriculum was to explore together with the trainees ways to use robotics as learning tool focusing on the phenomenon of motion and the basic kinematics concepts: time, distance, speed, motion at constant speed, motion at accelerated speed.

After the necessary familiarization with the Lego Mindstorms NXT kit (5 from 6 trainees were novice in robotics), where we followed the same methodology described earlier in this paper, we focused on laboratory activities intended to teach the phenomenon of motion and the relevant kinematics concepts.

Trainees worked in two groups of three exploring the following questions/problems and designing suitable laboratory activities focused on a robotic car. An ultrasonic sensor had been attached to the car to provide data for the position of the car (actually the distance from a wall).

1st question/problem: What is the relationship between the time of the motion which you type in the Lego Mindstorms interface and the real time motion of the robot?

The trainees chose different times through the software interface to move the robot and checked the relationship of those data with real time motion data of the robot measured with a timer. They filled in a table of values and a subsequent graphical representation. They found that software times were equal to those recorded by the timer.

2nd question/problem: What is the relationship between the number of rotations of the robotic motor you type in the Lego Mindstorms interface and the distance traveled by the robot?

The trainees measured the radius R of the wheels of the robot and calculated the theoretical distance expected to be traveled by the wheel in one full rotation ($2\pi R$). Then they checked experimentally whether the theoretical values (number of rotations x $2\pi R$) coincided with the actual distance traveled in each case by the robot. They made again a table of rotations and distance values and a subsequent graphical representation graphing the linear relation between the number of rotations typed in the software interface and the real distance traveled by the robot. Real distance was found almost identical to the theoretically expected and analogous to the number of rotations.

3rd question/problem: What is the relationship between the power of the motor you type in the Lego Mindstorms interface and the speed of the robot?

The trainees chose different values of motor power and measured the actual distance traveled by the robot at a certain length of time for each value of power. They filled in again a table of values and a graphical representation showing a linear relation between the two variables.

After these basic explorations they were invited to design an experimental activity of their own choice that would be useful for their students to study the rectilinear motion at constant speed. At this point the data logging function provided by the software Lego Mindstorms was introduced.

After several trials with the robot moving on the floor, the trainees devised the programming solution given in fig. 2 resulting in the linear graph (fig. 3).

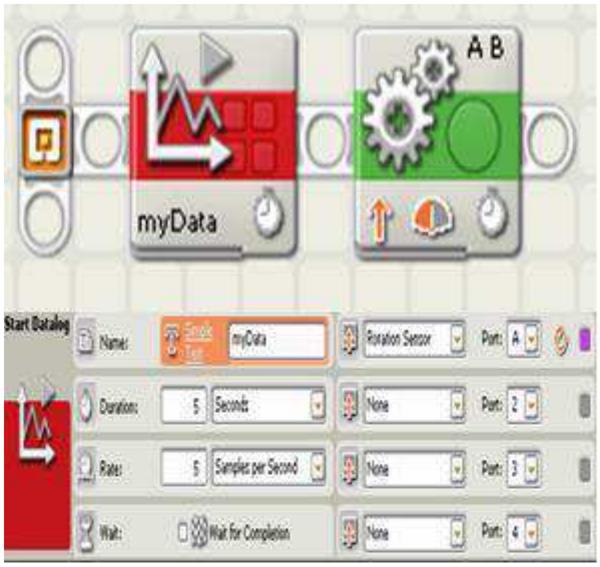

Fig. 2. Trainees' program for rectilinear motion at constant speed

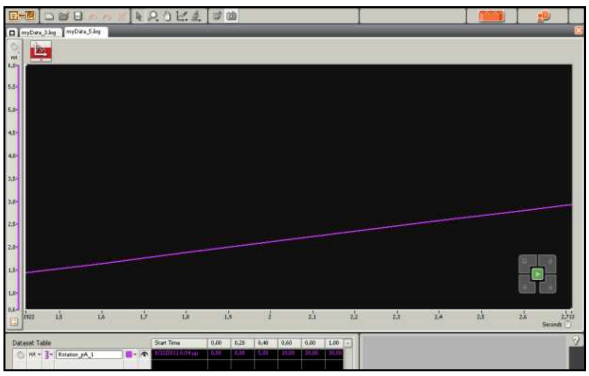

Fig. 3. Constant speed motion: Position-time graph (screenshot from data logging)

The next challenge was to make the robot move in rectilinear motion accelerated at constant rate. For this purpose, the programming technique of repetition and arithmetic operators were introduced. The result from trainees' programming work appears in fig. 4 and the subsequent position – time graph in fig. 5

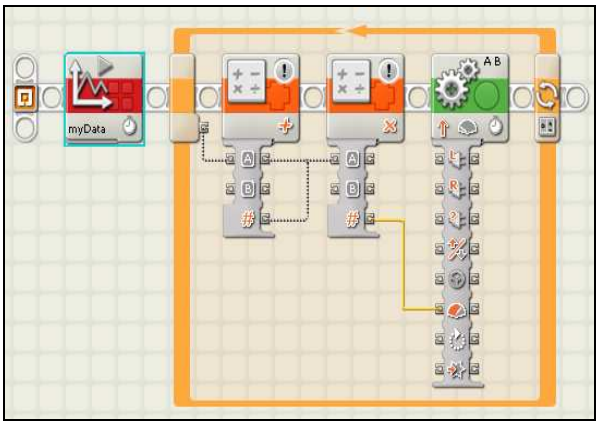

Fig. 4. Trainees' program for rectilinear motion accelerated at constant rate

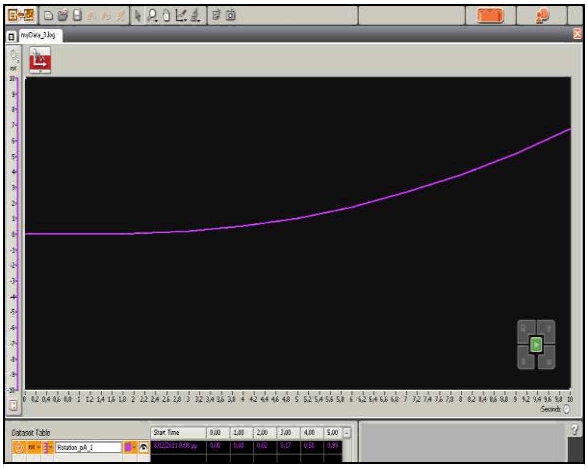

Fig. 5. Rectilinear motion accelerated at constant rate: position-time graph (screenshot from data logging)

In the discussion that followed for the evaluation of this training experience, we concurred with our experienced trainees that the methodology followed had resulted in a study of kinematics concepts through active participation of the learners; it could build step by step a deep understanding of the concepts triggering curiosity and encouraging further study and research. The use of robots had allowed repeated and controlled by the user interesting experimentations. Programming the motions and devising appropriate algorithms that result in rectilinear motion with constant speed or constant acceleration could help students in understanding the underlying kinematics concepts.

Finally, the execution of the programmed movements of the robot could help students to see their thinking, as expressed in the algorithm, to come alive with the robot moving on the floor and to understand their failures or achievements.

B. Teaching kinematics concepts in a school physics class through robotics

The methodology described in the section above was tested in a physics classroom (April 2012) by an experienced teacher, who had already been trained on the same methodology. In collaboration with the teacher the methodology was determined according to the needs of the school classroom. It was a class of 9 students aged 13 in a lower secondary school located in a poor rural and mountainous area of Western Greece (Ilia Prefecture).

Specific teaching materials including worksheets and assessment tools were developed for teaching and learning of basic concepts of kinematics including:

– rectilinear motion at constant speed
– relationship between distance and time of motion
– conceptualization and measurement of speed
– position-time and speed – time graphs.

More specifically, the students were divided into groups of three and initially became familiar with the Lego Mindstorms kit and the icons-based programming environment that comes with it. Then each group built their own vehicle.

We tok care to avoid detailed instructions for building because we wished to encourage students' initiatives, imagination and creativity in building the car in their own way.

Thus, the following purposely simple instructions were given through a worksheet:

Worksheet 1.

With your Lego Mindstorms kit build a car that has

– *Four wheels*
– *One motor that will actuate the 2 front wheels*
– *One Lego "smart brick" on the car*

Show your car in the classroom and put it in motion.

The 1st day activities ended with racing between the three vehicles, with the children to amuse and enjoy their artifacts.

During the 2nd day activities pupils worked according to the following instructions:

Worksheet 2

Put the car in motion.

Change the "throttle" of the motor, what do you observe happening in the movement of your car?

Although some confusion between the terms "speed" and "force" was observed in students' answers, they indicated understanding of the function of the motor power and its relation with the speed of the car. An indicative answer: "When we raise the throttle the speed and force goes up and when the throttle is lowered the motor power and speed is reduced". In our question: "What do you mean by the word force", they answered that the word "force" meant the "throttle" or "power" of the engine.

Then students were invited to experiment with the time of motion.

Worksheet 3

Put the throttle to 50% and do not change.

Put your car to move for 1 second

Then for 2 seconds
Then for 3 seconds
Observe what happens in the movement of your car when you change the time of motion?

All the three groups found that the distance traveled by their car was proportional to the time of motion: "as time of movement grows, the distance traveled by car increases". Then the students were challenged to make their car move faster and faster.

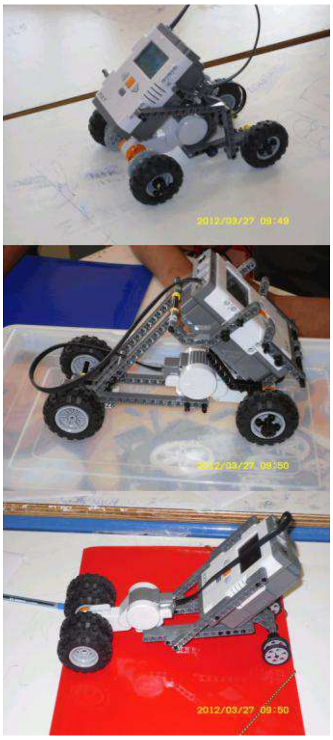

Fig. 6. Each student group constructed a different vehicle

Worksheet 4
How can you make the car move faster?
Again from the beginning: make it move even more quickly
Faster again and again ...
Try the solution you thought.
Enter here the solution you provided…

Students easily found that dragging up the slider of the power their car was moving faster: "Through the computer we increase the throttle and the car moves faster"

In the next activity the conceptualization and measurement of the speed was introduced.

Worksheet 5
How fast your car runs every time? Think of a way to measure how fast the car is running
Apply the way you thought and measure how fast your car goes.
Write the way you thought ...

The students essentially defined the concept of speed. They measured the distance traveled by the vehicle at a time specified through the Lego Mindstorms interface. For measuring the distance, they adjusted the tape very properly on the front wheels of the vehicle at a certain point and measured the distance traveled by that point. "*We went to the computer and set the car moving for 2 seconds at full power (100%). Then we went and measured the distance moved and found that the car does 80 cm in 2 seconds*".

Then the teacher insisted asking questions to detect students' understanding about speed: "*Can you tell what it means for you that the car goes fast or slow? Write your thoughts here*". Some students gave a numerical example that showed a good understanding of the concept: "*when two cars are running, one travels 500 cm in 2 seconds and the other 80 cm in 2 seconds*". The teacher insisted: "*Can you explain what is the 'swiftness' of your car? Write here…*" (we used on purpose a simple Greek word from everyday life meaning speed and not a scientific term in order to challenge students to express spontaneously their conceptions). "*Swiftness is when the speed and power of the car is big and make the car move faster and more comfortable*" was an interesting answer which tried to explain the informal term of "swiftness" using the scientific ones of speed and power. The day activity ended (as usual!) with improvised races between the vehicles.

Finally, during a 3rd school day, the students studied the linear motion at constant speed working with the following activities.

Worksheet 6
Keep the "throttle" of the motor constant at 50%.
Count distances your car makes when it moves for different times.
Calculate each time the speed of the car. What do you observe?
Make a table with your data and graph the values of distances, times and speeds measured.

Students successfully approached the concept of a linear motion at constant speed; they easily found that the speed remained constant at each measurement they had made; the concept was also reflected in the graphs distance-time and speed-time made with paper and pencil.

Diaries were written in the end of each day with students' experiences: "*What went well today in what you did with your team? What did not go well? What you liked most of what you did today? What did not you like from what you did with your group today?*"

From the diaries it appears that the most enjoyable moments of the children were at the end of each day when they used their cars in improvised racing: "*I liked most when we put the battle carts and although ours is the heaviest it came out first*", "*I didn't like that sometimes we were defeated in the race by the other children due to our engine failure*".

The children's excitement with the game of racing introduced in the learning activities some fun which seems that resulted in game-based learning and motivated the students to make improvements and interventions in the construction of their vehicles to make them faster and more competitive. As stressed by Lund & Nielsen, learning is easier, faster and more effective when combined with the game and turns education into a fun activity [10].

When students were interviewed in the end of the course, they mentioned that across the whole educational process they had found as most interesting the assembly and construction of the vehicle. They emphasized the excitement they had felt "*when we set in motion our car*" and their satisfaction from their collaboration and team work.

Answering the question "*what new did you learn in this course?*" the students appreciated the understanding they had gained for the kinematics concepts. However they were impressed with their achievement in construction and programming the robotic vehicle. To put it in students' words "*it was surprisingly easy to build the robot…*", "*at first we thought we would never be able to build robots that we had seen only in pictures… but we did*".

Fig. 7. Students' car racing

After the end of the course the teacher reported his experiences from the course [11]. It is interesting to quote some of them: "… I obsereved that students' behavior showed that they had tried to impose their own ideas, ignoring or modifying the instructions given by the teacher. For example the red team did not use equal-sized wheels which resulted in a non-robust construction, but they insisted on their original idea that eventually changed gradually…. the white group used initially six wheels (instead of the proposed four) because they found it more attractive from an aesthetic point of view".

In another case the teacher noted the efforts of some children to experiment with different solutions while constructing their vehicle: "*in this group there was a strong tendency for many tests in the construction and use of many different parts*". Interestingly, he noted that the students who come from agricultural families and are dealing in their everyday life with agricultural and manual work from an early age had performed better in the construction of the robot. As he commented "*these children had learnt to use and operate agricultural machinery; this had strengthened their skills in assembling and manufacturing mechanical vehicles*".

The teacher's report concluded that "*the robotics-based teaching method followed in this project had effectively helped students to achieve cognitive goals in physics and technology, to acquire skills and competencies and solving problems*". Finally, "*the students had appreciated the value of teamwork and cooperation*".

V. Conclusions and Future Plans

This work highlighted two pathways for integrating robotics in teacher training: first in the initial education courses for technology teachers and second in the further training programs for in-service science teachers. A constructivism-inspired learning methodology was proposed in both cases specified according to the specialization, needs, interests and existing educational experience of learners. The active involvement of the trainees in all the phases of the training course was an important characteristic of the training methodology. From the beginning of the course, trainees were encouraged to participate in all the practical activities of the course, in discussions in small groups, and finally in presentations in plenary sessions. In line with previous findings [12], teachers appreciated the rotation of their role acting first as learners in the training courses, then as designers and developers of their own robotic projects in school classes. In this way teachers had the opportunity "to see themselves as designers of technologically rich curricula, and not merely consumers" [13].

In the second case of the experienced teachers a specific methodology was selected that focused on utilizing the existing rich experience of trainees and on sharing with them the effort to explore new ways to use robotics in learning science. Teachers achieved, after an initial familiarization with the necessary tools, to create through their own efforts and in collaboration with their trainer experimental robotics-based activities which they considered useful for their students in order to understand the intended in each case scientific concepts by following the constructivist methodology proposed in the training course.

In both cases, training was followed by development of projects in school classes by the trainees themselves where they were asked to implement the pedagogic ideas offered and discussed during their training. The classroom experiences, as demonstrated by the two reported case studies, offered a criterion of success of the training program itself and confirmed the effectiveness of the proposed robotics-based methodology in understanding scientific concepts from the field of informatics and physics, and developing skills with a more general value for students beyond the two mentioned specific fields. Furthermore, the reported activities seemed to have triggered the students' interest and turned, to a certain extent, learning into a game thanks to their invention of the competitive car-racing. We concur at this point with Polishuk et al. [14] that the combination of competitive with developmental activities is suitable for fostering both creativity and learning excellence.

The field of science and technology is a privileged one for the development of robotics either in school education or in informal settings. Acting in close collaboration with both enthusiastic young and experienced teachers we plan further experimental activities including teacher training and classroom interventions which are expected to provide valuable new ideas and data for the successful integration of robotics in the school curriculum of science and technology. Ideally, this work might result in a proposal for a school curriculum that would highlight the role and value of robotics in teaching and learning in a broad range of school disciplines with emphasis on science and technology.

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SCIENCE TECHNOLOGY ENGINEERING MATH 3. According to the US Department of Education, more STEM education is needed in order for America to remain a global leader. Only 16% of 12th graders are proficient in math and interested in the STEM field. 4. STEM job opportunities, however, continue to grow.Â As an innovator in the field of industrial robotics, KUKA supports STEM education. 8. KUKA Robotics' KORE Program allows high school, technical center, and college students to learn about robot programming and operation. 9. KUKA KORE provides hardware packages to students to encourage their engagement with STEM technologies. 10. To learn more about STEM education and KUKA KORE, visit www.kukaconnect.com. From robotics in education's beginnings, to the programs and kits available today, and the competitions that challenge students worldwide.Â One of the next iterations of robotics education was LOGOâ€™s collaboration with Lego, first controlled through personal computers, and later in the form of fully programmable bricks. This became what we know today as Lego Mindstorms. Lego has continued to provide educational programs with its products for grades Kâ€“12, with a variety of robotic capabilities. In addition to Lego, many companies now provide robotic building kits that educators can use to build systems thinking, learn engineering, and practice STEM concepts, following the theories of constructionism.