Introducing robotics in schools: post-TERECoP experiences from a pilot educational program

Dimitris Alimisis

School of Technological and Pedagogical Education, Patras, Greece
alimisis@otenet.gr

Abstract. This paper presents a pilot educational program implemented in schools of Athens aimed to introduce robotics in primary and lower secondary education. The learning activities were designed according to a constructionist methodology. 68 pupils were engaged in team work to construct and program robotic vehicles using Lego Mindstorms technology and in the creation of their own free robotics project. Pupils' free projects and their diaries written in the end of each day/session provided some very promising evaluation results indicating pupils' good achievements, enthusiastic attitudes and interesting social interactions.

Key words. Educational robotics, Lego Mindstorms, constructionism

1 Introduction

The program reported in this paper continues the "tradition" of the European project TERECoP activated during the years 2006-2009 with the participation of 8 European educational institutions from 6 European countries [1]. A design and implementation framework was developed by TERECoP for learning activities related to programmable robotic constructions, inspired from constructivism and constructionism theory and advisable for school education [2].

The next step, already started, is the implementation of those ideas in real school class settings. Teachers who have been trained in educational robotics by the TERECoP partnership and have become members of the TERECoP community support our experimentations in schools. Experiences coming from these implementations provide valuable feedback for evaluating and revising continuously our methodologies, tools and materials.

A pilot program for introduction of robotics in schools of Athens was realised during April-May 2010 by a consortium consisted of the non-profit organisation *World Robotics Olympiad Hellas* [3], the *Athens Municipality (program "schools go Athens"* [4] under the educational auspices of the *Educational Technology Lab of ASPETE in Patras, Greece*. The educational objectives of the program included the familiarization of pupils with robotics technology, the acquirement of technological skills in mechanical construction and in programming, the cultivation of valuable mental skills such as creativity and critical thinking and the development of teamwork and collaborative spirit of work.

Proceedings of SIMPAR 2010 Workshops
Intl. Conf. on SIMULATION, MODELING and PROGRAMMING for AUTONOMOUS ROBOTS
Darmstadt (Germany) November 15-16, 2010
ISBN 978-3-00-032863-3
pp. 575-585

The program came just a few months after the official end of the TERECoP project and offered a good opportunity to design and test a course following the constructionist theoretical framework and learning methodology developed by the TERECoP project. According to the TERECoP approach [5], learners build something on their own, preferably a tangible object that they can both touch and find meaningful. Learners are invited to work on experiments or problem-solving with selective use of available resources, according to their own interests, search and learning strategies. They seek solutions to real world problems, based on a technological framework meant to engage students' curiosity and to initiate motivation. In such an environment, teachers act not as instructors but rather as facilitators, organizing and supporting pupils' activities [6].

In this paper, we focus on the implementation of this methodology in real school class settings and we attempt to observe pupils' work through their projects, their reactions towards the proposed activities and their social interactions within their groups through their own eyes (that is through their diaries). For this purpose, pupils' experiences from that program, as they were recorded in their diaries, are reported and discussed in an attempt to shed light in the ways that TERECoP learning methodology functions in classroom settings and in pupils' individual responses and social interactions as well.

In the next sections, data and details are provided for the pupils who participated in the program, for the learning activities implemented and for the projects realized by the pupils. The evaluation of the course follows based on pupils' projects and diaries and the paper finishes with discussion of the findings, conclusions and recommendations.

2 Sample data

68 pupils aged 11-14 years from 6 schools (3 primary and 3 lower secondary ones) located in 6 different areas of the Athens city centre participated in the program. The great majority were novices in educational robotics:

- 89.71% of them participated for first time in a course on educational robotics
- 77.95% had none or little previous experience with educational robotics.

3 The learning activities

The learning activities were aimed to:

- engage pupils in activities for designing and realizing programmable robotic constructions
- encourage and support pupils to experiment and explore the ideas behind their constructions

The LEGO Mindstorms NXT [7], a system that offers building materials (regular blocks, gears, pulleys, axels etc.), sensors (light, touch, sound etc.) allowing the robot connection with the external environment and programming software with a simple

Proceedings of SIMPAR 2010 Workshops
Intl. Conf. on SIMULATION, MODELING and PROGRAMMING for AUTONOMOUS ROBOTS
Darmstadt (Germany) November 15-16, 2010
ISBN 978-3-00-032863-3
pp. 575-585

graphical interface intended for the creation of robot behaviours, was selected to be used as a tool that can partner technology with the ideas of constructionism [8].

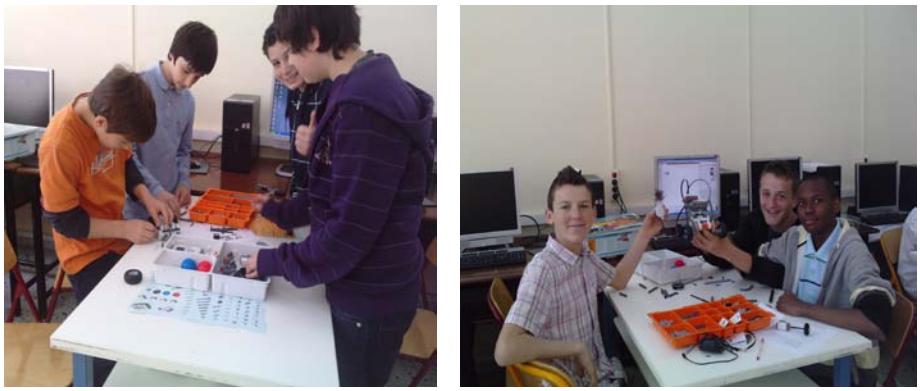

Fig. 1. Pupils in action during the robotic activities

The activities were held in three separate sessions of four hours each for three consecutive Saturday mornings during April-May 2010.

1st session (4 hours)

- A brainstorming activity (10′) takes place with the pupils answering the teacher's question: *what is a robot?*
- The teacher assigns the pupils to construct a simple vehicle explaining shortly the Lego Mindstorms elements to be used later in the learning activities (30′)
- The pupils are separated in groups of 3 or 4. One Lego Mindstorms set is available for each group. Pupils are invited to
- talk about the assigned construction
- sketch with paper and pencil the under construction vehicle
- construct the vehicle using the Lego Mindstorms set
- Each group selects one representative to present their construction to the whole class (15′)
- Teacher and pupils note their experiences in a diary answering the following questions: what did you do today with your group? What went well? What went well? What did not go well? What did you like more? What you didn't like?

2nd session (4 hours)

- The teacher presents (45′) the basic functions of the Lego Education NXT software including
  - motion commands (blocks)
  - control with the command (block) "wait"
  - use and function of the sensors (touch, light, sound, distance)
  - use of the controller (NXT brick) for downloading programs from PC to the NXT brick
- The pupils make their own experimentations in using the software with the vehicle they have already constructed (120′)

Proceedings of SIMPAR 2010 Workshops
Intl. Conf. on SIMULATION, MODELING and PROGRAMMING for AUTONOMOUS ROBOTS
Darmstadt (Germany) November 15-16, 2010
ISBN 978-3-00-032863-3
pp. 575-585

- Each group selects one representative to present their work to the whole class. The teacher offers comments and advice when it is necessary (40´)
- Teacher and pupils note their experiences in a diary (5´).

3rd session (4 hours)

Pupils are invited to design and realize a free team project according to the following scenario: *let's imagine that your robotic vehicle moves in the city centre. Talk in your group what you would like for your vehicle to be capable of doing. Describe by paper and pencil your plan in your worksheet.*

- The pupils talk about their project and write down their ideas by paper and pencil (20´)
- The pupils realize their ideas programming their vehicle according to their project plan (120´)
- Each group presents their work to the whole class. The teacher offers comments and advice when it is necessary (80´)
- Teacher and pupils note their experiences in a diary (5´).

4 Evaluation of the program

Several tools were used for the evaluation of the different aspects and objectives of the program: diaries by pupils and teachers, questionnaires, pupils' works, and teachers' reports. In this paper, we focus on pupils' work realised in free projects and on their diaries written in the end of each day/session, because they can provide useful insights in pupils' achievements, experiences and reactions towards the implemented methodology. Other interesting insights driven from the observation of the pupils' work in class, from the questionnaires and from the teachers' reports will appear in other publications.

4.1 Pupils' free projects

The projects realized by pupils during the 3rd day of the course are presented shortly below as they were reported by their teachers.

- Simulation of road motion: When the robot-car detects a starting sound starts moving forward. It moves backwards or stops when detects sound or obstacle in a distance (12 cases)
- pupils added 2nd motor and the robot-car turns right when detects sound (1 case)
- simulation of behaviour in front of traffic lights: when the robot-car detects green/orange/red colour it accelerates/decelerates/stops correspondingly (2 cases)
- pupils added 2nd motor, robot-car follows a straight path, then it turns right and parks in a pre-defined area (2 cases)
- pupils added 2nd motor and 2 touch sensors, the robot-car follows a straight path and turns right or left when a touch sensor is pressed (1 case)
- pupils added 2nd motor, the robot-car moves along a square drawn on the ground (2 cases)

Proceedings of SIMPAR 2010 Workshops
Intl. Conf. on SIMULATION, MODELING and PROGRAMMING for AUTONOMOUS ROBOTS
Darmstadt (Germany) November 15-16, 2010
ISBN 978-3-00-032863-3
pp. 575-585

- pupils added 2nd motor, robot-car moves along a straight path with 2 lanes drawn on the ground, it reverses route in the end of the path and comes back following the opposite lane (2 cases)
- 2 robots (made by 2 groups) meet in a street corner, recognise each other, stop and give priority, produce sound, wait and move again according to traffic rules (1 case).

Characteristic examples of projects are given below quoting pupils' words:

- "Our car will start moving and will stop 10 cm before a red traffic light; when it turns to green the car starts again. A pedestrian appears in the road, the car sees him, turns right and passes by him to avoid hitting him and continues telling "fortunately I didn't hit him"
- "we programmed our robot to do strange things: when there was silence in the class it was moving forward and when there was noise it was moving backwards"

4.2 Synopsis of pupils' diaries

1st day

What did you do today with your group?

Pupils' diaries focused on the construction task that appears to have been an interesting and appealing activity: "we made a robot car, I am so happy", "we made several funny things…", "we made a vehicle, we named it "car" and of course we enjoyed it". In few cases pupils noted that they had not participated actively in the task ("I just watched the others…") due in another case problems with their group ("I did nothing, they did not allow me to participate").

What went well?

The majority noted that everything went fine, others emphasised the good collaboration they had with their mates ("my collaboration with Stavros"), their success with the construction task ("we succeeded to construct the car as we imagined it", "the construction was made as we wanted it") and in some cases they compared their good work to other teams' failures ("we succeeded to construct a car that worked and was not destroyed after the first motion in the class as it happened with other teams' robots").

What did not go well?

Most diaries noted "nothing to mention". In few diaries some problems encountered were noted referred to errors occurred, failures with the construction task ("it took too long to make the robot car"), confusion ("in the beginning we were lost"), bad collaboration in the group ("we quarrelled and we could not collaborate", "some things with Thodoris").

What did you like more?

"Everything" is a common answer in this section of the diaries. Many pupils noted that they had enjoyed the work and the successful finalisation of the construction task ("when we were constructing the car…", "when I saw that the robot was ready", "the robot was super!", "when I saw the robot moving I felt shocked"), others had liked more the collaborative work ("I liked that we made the car as a team all together"), emphasised the playful class atmosphere ("we worked as friends and the time passed joyfully", "we talked, laughed, told jokes…", "we made a robot and new friends")

Proceedings of SIMPAR 2010 Workshops
Intl. Conf. on SIMULATION, MODELING and PROGRAMMING for AUTONOMOUS ROBOTS
Darmstadt (Germany) November 15-16, 2010
ISBN 978-3-00-032863-3
pp. 575-585

and the freedom they had to select materials for their robot ("we had plenty of pieces and materials to built the vehicle as we wished to").

What you didn't like?

Most diaries had "nothing to mention". Others noted the technical difficulties they had encountered with the construction task ("finding the different pieces for making the robot") while others complained that their car design didn't allow it to turn. Some diaries emphasised bad collaboration and negative behaviours in their team: "only boys in the group, I was watching the others" by a girl, "I didn't like my group, they did not allow me to participate" by a non native pupil, "I didn't like the high self-confidence of the leader of our team", "Thodoris did not follow teacher advices", "Eleftheria and Thodoris were quarrelling all the time…". In some diaries an antagonistic mood among pupils was reported: "I didn't like the cars of the others…", "our robot was less beautiful than the others".

There were also some interesting diaries criticising methodological issues of the session: "I didn't like that the teacher decided what to construct", "in the beginning of the session the teacher talked too much explaining robots…", "I didn't like the talk in the beginning of the session". There was one diary complaining for "the noise in the class" but in the majority of the dairies it was apparent that pupils had enjoyed the session: "I didn't like the short time" (4 hours!), "I didn't like the idea that I had to wait for the next Saturday to continue…"

2nd day

What did you do today with your group?

The diaries focused on the programming task that was the main activity during the 2nd day. Pupils reported clearly (and in some cases with humour) their programming work indicating their full awareness of their achievements: "we programmed our robot to do strange things: when there was silence in the class it was moving forward and when there was noise it was moving backwards…", "we programmed the robot car to stop when meets black colour". Their work with sensors is also reported in human terms: "we made a robot with eyes and ears". Problems within groups are once again reported: "I didn't anything, they did not allow me to participate (by a non native pupil", " I did almost nothing, **they** made the robot and it run) (by a non native pupil).

What went well?

Most of diaries reported that everything had gone well: "everything! We finished 15 minutes earlier and we had time for several tests with our robot".

What did not go well?

The stereotypic answer to this question was "nothing to mention".

In some diaries complaints were reported for malfunctions of sensors regarding especially light and sound sensor: "I was nervous because we programmed it to stop when it sees …but it did not work". It seems from other diaries that pupils encountered difficulties in programming their robot: "sometimes the robot did not responded well and we had to check the program again", "the program did not work and we were nervous". Collaboration within some groups didn't go once again well: "my collaboration with Antypas, he was aggressive", "I was quarrelling with Antony and Bill ", "I undertook only few things to do". Once again some pupils complained because their car was not capable to turn right and left: "it cannot turn!".

What did you like more?

Proceedings of SIMPAR 2010 Workshops
Intl. Conf. on SIMULATION, MODELING and PROGRAMMING for AUTONOMOUS ROBOTS
Darmstadt (Germany) November 15-16, 2010
ISBN 978-3-00-032863-3
pp. 575-585

Answers focus on the programming work and the resulting behaviours of the car: “we made the robot to run”, “when we made commands”, “we discovered how many things we can do with robots”, “when the robot moved”, “we clapped and talked to our robot to start moving”, **“**I liked to see the sensations of the robot to work”, “our car runs so fast like a Ferrari”. Some diaries focus on the presentation of pupils’ work in front of the class: “when we presented our robot”. In some cases the pupils underok the initiative to experiment adding more advanced elements to their construction: “our effort to add gears to our car…”

What didn't you like?

Similarly to the 1st session most diaries had “nothing to mention” here. A few pupils didn’t like the light and sound sensors (possibly due to the above mentioned their malfunction) and the cable they had to use to connect their robot with the PC. Some didn’t like filling in the worksheets or writing the diary! There was criticism for the time that the teacher seems had spent for conversation: “we spent one hour in the beginning of the lesson talking”. Finally, complaints for poor collaboration within some groups were reported: “I liked everything but I did not anything”, “I didn’t like my group” (by non native pupils).

3rd day

What did you do today with your group?

The diaries describe the free team project that pupils had been invited to design and realize according to the scenario of a robotic vehicle moving in the city centre: “we made a robot to turn and park”, “we programmed our robot to "see" pedestrians in order not to avoid stepping on them but not to be stepped by them” (!)

What went well?

Everything seems that had gone well for the great majority.

What did not go well?

Some pupils reported inconveniences once again with light and sound sensors: “the sound sensor made us nervous…”, difficulties in programming their robot to turn, and interestingly difficulty in selecting their project: “we had so many ideas that it was difficult to choose…” (!)

What did you like more?

The diaries referred mostly to pupils’ experiences with their robots: “I liked that we made a robot that we could use as we wished to”, “when our robot turned”, “when we made the robot to move and turn”, “our robot was talking to us”, “when the sound sensor worked after 1000 trials” (!) Another interesting remark: “I liked more the fact that the subject of the today lesson was free”.

What didn't you like?

Most diaries had nothing to mention. Some pupils reported they didn’t like the light and sound sensors which had caused the pre-mentioned troubles, complained for imbalanced use of programming environment within their group (“always the same pupil used the PC”) and for the worksheet where they had to sketch their project.

Proceedings of SIMPAR 2010 Workshops
Intl. Conf. on SIMULATION, MODELING and PROGRAMMING for AUTONOMOUS ROBOTS
Darmstadt (Germany) November 15-16, 2010
ISBN 978-3-00-032863-3
pp. 575-585

5 Discussion

The dexterity and creativity shown by pupils when they designed and realized their projects during the 3rd day of the course indicates that the two first sessions succeeded in familiarizing pupils with Lego Mindstorms technology and equipped them with the necessary skills for the successful robotic construction and programming work in the frame of the free project. There was a variety of projects created by the pupils following the open scenario of a car moving in the city centre. In all the projects the pupils equipped their vehicles with sensors to enable their robots to communicate with the external world and to achieve very practical behaviors. In many cases pupils imagined their cars doing "strange things" like trying to avoid stepping on pedestrians or in another version (favoring the robot against humans!) to avoid to be stepped by pedestrians!, to follow traffic lights according to traffic rules, and to move forwards or backwards according to the noise existing in the class.

It is interesting (although not surprising) that some enthusiastic pupils wanted to build a more flexible mobile robot capable not only for linear motion forwards and backwards but capable to turn right and left as well. Some groups did attempt to do so adding a second motor to their robot with their teacher help, although this task had not been included in our initial work plan. Designing this program we wanted to offer activities that should have a "low floor" [8] easy to get started since they were addressed to pupils being novice in robotics. Obviously some pupils would prefer a "higher ceiling" to have been available at their work that would have allowed them to experiment at a higher level. The variety of the different free projects developed by pupils may imply their desire for "wide walls" as well that would support pupils with different interests and learning styles to be engaged. Besides the time restrictions (we had only 12 hours available totally), we agree with Resnick et al [9] noting in another occasion (Scratch programming language) that satisfying the triplet of "low floor / high ceiling / wide walls" is not an easy task.

Other groups experimented with the use of gears in their vehicle without success. It was obvious that the pupils wanted to try everything in range being curious and enthusiastic to learn doing more and more. This explains some pupils' complaints for the short duration of the sessions and of the total course.

Some other interesting findings emerge from the diaries. First of all pupils provided short but clear descriptions answering the question "*what did you do today with your group?"* showing that they had full awareness of what they had been doing in the class either constructing their robots or programming them and experimenting with their free project.

Although during our initial planning we suggested to teachers to provide a very short introduction in the beginning of the course and short oral interventions during the course only when it was necessary, some pupils, not surprisingly, criticised in their diaries the teacher's introductory talks as too long. They wished "to do more and watch less"; to save time for their practical activities. In all the sessions their preference for the practical activities was apparent; they liked the construction of the robot car (1st day), they enjoyed creating behaviours for their robots through the use of sensors and programming work and appreciated the opportunity to do their free team project but they didn't like listen passively to their teacher's speech, filling in their worksheets or writing diaries.

Proceedings of SIMPAR 2010 Workshops
Intl. Conf. on SIMULATION, MODELING and PROGRAMMING for AUTONOMOUS ROBOTS
Darmstadt (Germany) November 15-16, 2010
ISBN 978-3-00-032863-3
pp. 575-585

It is also interesting that when failures or errors were occurred, pupils insisted in testing again and again their robots until achieving the desired solution ("I liked more when something went wrong and we tried to find a solution"). They expressed their joy and satisfaction with their artefacts when they had finalised them and made them to run: "«I liked more we learnt to make robots using simple Lego pieces" "I liked more we accomplished to make our robot to move…" On the contrary, they felt disappointed and nervous in case of failures. These pupils' reactions indicate their high engagement in the activities.

There was a special preference for the free project done during the 3rd day. In general it seems that they liked to realise their own designs and plans, not just to follow teacher's instructions ("I liked we might make our robot as many times as we wished to and in different ways"). The free project allowed them to imagine (with a certain degree of freedom limited by the time restrictions) what they to do, to create their own project, to play and experiment with their creations, to share them with the other pupils in class and to reflect on their experiences (in class and in diaries) following an approach that resembles to what Resnick calls "creative thinking spiral" [10].

Although in many cases pupils appeared to have enjoyed the team work in their group, it seems that not all the kids were activated in construction and in programming work, due mainly to bad collaboration within groups. Several problems were reported including antagonistic behaviours, quarrels and marginalisation for some pupils by the "leader" of the group. Girls (when belonged to male groups) and non native pupils seem to have been the more "vulnerable" group. A kind of rivalry between groups was observed. Some pupils tended to compare their work to that of the other kids and of course they found their projects better than the others.

A few pupils, probably having experienced for years the traditional teacher-cantered classes, felt annoyed with their "noisy" and messy class. Apparently the atmosphere was very different from the silent traditional school classes which are usually dominated by the teacher's speech. The organisation of our robotic classes was pupil-centred, encouraging the active participation in groups and practical work which means a lot of talks within and between groups resulting in a "noisy" and possibly messy class.

It is worthy to note that when pupils equipped their robots with sensors, they used to see their robot as a human or an animal having eyes, ears and hands, they worried and took care for their robot ("not to be stepped by pedestrians") or they interpreted the sounds emitted by the robot as a kind of communication between them and the robot ("our robot was talking to us").

6 Conclusions and recommendations

One challenge emerged from the program reported above is the necessity for designing learning activities in such a way that might satisfy the above mentioned triplet of "low floor / high ceiling / wide walls" [9]. For this purpose richer equipment available in class and longer duration of the course are necessary, but above all we have to design and propose learning methodologies flexible enough to be adjusted to

Proceedings of SIMPAR 2010 Workshops
Intl. Conf. on SIMULATION, MODELING and PROGRAMMING for AUTONOMOUS ROBOTS
Darmstadt (Germany) November 15-16, 2010
ISBN 978-3-00-032863-3
pp. 575-585

pupils' interests and preferences, giving more space to their initiatives and imagination.

The episodes of curiosity and enthusiasm that were observed among pupils once again in this program were very similar to those happening often in classes working with robotics in (and out of) schools [5] [11] [12] [13]. These attitudes are a very positive factor for the engagement of pupils in robotics-based learning activities. However, we need to integrate them in a well-thought curriculum that, on the one hand, will trigger pupils' curiosity and enthusiasm but, on the other hand, and beyond the mere satisfaction of pupils' feelings of curiosity and enthusiasm, will exploit and transform them to a sound educational factor leading to a more conscious and mindful engagement in problem solving and in other creative activities.

Finally, findings emerged from this program suggest to pay more attention to the social interactions taking place in the microcosm of pupils' groups or in school class as a whole. Bad collaboration, negative relationships or aggressive behaviours within groups and class may cancel the educational advantages of robotics if they inhibit participation in group activities and result in marginalisation of the more vulnerable pupils which in the case of this program seem to have been children of immigrants and girls. So, the design of the course should consider carefully the social interactions happening in class and should offer a more socially sensitive program assuring equal opportunities and broadening participation for all the kids [14].

Acknowledgments. I would like to thank all the teachers and pupils who worked enthusiastically in their classes and contributed to the successful implementation of the project reported in this paper. Many thanks also to the co-organisers of this program, the non-profit organisation "World Robotics Olympiad Hellas" and the Athens Municipality, for the excellent organisation of this program and for the support they offered to teachers and pupils.

References

1. Project Teacher Education in Robotics-enhanced Constructivist Pedagogical methods-TERECoP, COMENIUS 2.1 Action, 2006-2009, http://www.terecop.eu
2. Alimisis, D. (ed.) Teacher Education on Robotics-Enhanced Constructivist Pedagogical Methods, Published by ASPETE, Athens (2009).
3. WRO HELLAS, http://wrohellas.gr (in Greek)
4. Program "schools go Athens", http://www.cityofathens.gr/en/node/8763
5. Alimisis, D., Arlegui, J., Fava, N., Frangou, S., Ionita, S., Menegatti, E., Monfalcon, S., Moro, M., Papanikolaou, K. and Pina, A. Introducing robotics to teachers and schools: experiences from the TERECoP project, in J. Clayson and I. Kalas (eds.) Proceedings for Constructionism 2010, 16-20 August, 2010, Paris, France, (2010)
6. Papert, S. The Children's Machine. N.Y: Basic Books (1992)
7. LEGO Mindstorms NXT , http://www.legomindstorms.com
8. Papert, S. Mindstorms: Children, Computers, and Powerful Ideas. N.Y.: Basic Books (1980).
9. Resnick, M., Maloney, J., Monroy-Hernández, A., Rusk, N. Eastmond, E., Brennan, K., Millner, M., Rosenbaum, E., Silver, J., Silverman, S., Kafai, Y., Scratch: Programming for All, Communications of the ACM, vol. 52, no. 11, November (2009).

10. Resnick, M., Sowing the seeds for a more creative society, Learning and Leading with Technology, Dec. 2007, 18-22 (2007)
11. Arlegui, J., Demo, G.B., Moro, M., Pina, A.: Discussing about IBSE, Constructivism and Robotics in (and out of the) Schools. In: Proceedings of the Constructionism 2010 Conference, 16-20 March 2010, Paris, France (2010)
12. Arlegui, J. Fava, N. Menegatti, E. Monfalcon, S. Moro, M. Pina A. Robotics at primary and secondary education levels: technology, methodology, curriculum and science. In Proceedings of the 3rd International Conference ISSEP, Informatics in secondary schools, Toruń, Poland. (2008)
13. Petrovič, P., Balogh, R. Educational Robotics Initiatives in Slovakia, in Proceedings of the SIMPAR 2008 conference/Workshop "Teaching with robotics: didactic approaches and experiences", University of Padova, pp. 122-131 (2008).
14. Rusk, N. Resnick M., Berg, R., Pezalla-Granlund M. New Pathways into Robotics: Strategies for Broadening Participation, J Sci Educ Technol. 17: 59–69 (2008)

Proceedings of SIMPAR 2010 Workshops
Intl. Conf. on SIMULATION, MODELING and PROGRAMMING for AUTONOMOUS ROBOTS
Darmstadt (Germany) November 15-16, 2010
ISBN 978-3-00-032863-3
pp. 575-585