The Potential of Laboratory Educational Robotics in Primary Schools*

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Abstract

Theoretical work and test applications suggest that educational robotics constitutes an important means in learning, cognitive development and in other skills and dexterities in school. This study examines the feasibility of introducing to schools a laboratory of educational robotics as an educational environment e.g. the LOGO educational environment, which was designed and to some extent utilized. An innovative teaching approach is presented for the education of teachers, aiming at the acquisition of basic skills for school teaching. This approach was tested within the context of an undergraduate laboratory course of educational robotics in the Department of Primary Education at the University Crete. The results reveal that the introduction of a laboratory of educational robotics in primary school education is feasible.

Keywords: *Laboratory of Educational Robotics, Primary education, Robolab*

1. Introduction

In today's technologically dependent societies, learning new technologies must constitute a priority. The European Union encourages the literacy of such new technologies, aiming at accelerating the formation of high quality facilities and equipment at reasonable cost and the promotion of digital training and universal digital knowledge (see e.g. activities and programs on the website http://ec.europa.eu/education/index_en.html). Similarly, UNESCO (www.unesco.org) supports Science and Technology literacy and considers it a "right to democracy." Due to the rapid advances in Science and Technology, *social learning* according to Vygotski cannot be achieved, unless it is directed and addressed through compulsory education. In the realm of compulsory education, where its main objective is the development of complex cognitive skills and abilities and the gradual social integration, it is burdened with the acquisition of Scientific and Technological knowledge, abilities, and behaviors to be assimilated in the future society of knowledge. It is obvious the achievement of this cannot be accomplished through teaching, which focuses mainly on declarative knowledge but demands general reconstruction of the educational system in order to create the prerequisites of the appropriate framework of learning, e.g. seeking a new educational environment. The laboratory of educational robotics, based on constructionalism (Papert, 1980), seems to constitute a suitable educational environment (Bers, Ponte, Juelich, Viera, and Schenker, 2002; Costa & Fernandes, 2004), where the user (student) is in a position to construct and direct a robot with the assistance of a visual programming language.
The "Laboratory of Educational Robotics":

- Offers an experimental environment of try outs and inguiry from the students and suitable trained teacher for the development of complex cognitive skills. In reality it can be thought of as an evolution of the LOGO enviromnment, which was introduced in the early 70's by Papert (Papert, 1980: Logo Foundation).
- Constitutes a good example of current technology supporting also, cognitive construction skills. Teachers and students both have the opportunity to become acquanted with new methods and materials and with the functional usage of technology that allows them to exercise in changes of the (physical) world.
- Promotes cooperational learning through team work.

In previous publications the designing and the development of an undergraduate laboratory course entitled "Laboratory of Educational Robotics" with its basic aim the concept and the operations of a robot, the development of complex cognitive skills and the familiarization of current technology has been presented (Anagnostakis & Michaelides, 2006). As well as the results of pilot teaching, as a semester undergraduate course (Anagnostakis & Michaelides, 2007). Aside from the necessary facilities and equipment, crucial parameters for the creation of an educational environment and its effective usage are: i) teachers' knowledge pertaining to the educational environment, ii) ability to utilize the educational environment, iii) acceptance by the students.

In this study these variables are examined, specifically:

- Can the teacher teach the subject matter and cover personal deficits (on the subject) either alone or with the least re-training assistance?
- Can the students follow such a class in a fashion compatible to the school's aims and objectives, especially during compulsory education (acquisition and development of cognitive and other skills, abilities, and dexterities for their smooth integration as citizens of a democratic society)?

It is noted, that while subject matter is evolving constantly, those who teach in schools lack of any knowledge pertaining to subject matter. Constant re-training is required in a broad climax that will not create any problems in the school's daily routine and with a teaching approach that is directly useful (polymorphic teaching) (Michaelides, 1998).

2. Methodology

For the investigation of the above questions teaching was utilized, during the winter semester 2007, in an undergraduate course "Laboratory of Educational Robotics" as follows:

- The sample was 35 students; 7 males and 28 females from the Department of Primary Education, who took the course "Laboratory of Educational Robotics" (Anagnostakis & Michailides 2007). The equipment used by both group classes was Lego Mindstorms© (http://mindstorms.lego.com/). The instalment of the software for the programming of the robot, was on Mac lab tops to secure the easy transfer from the Department's laboratory to schools. The students did not have sufficient experience on the said computers. The programming of the robot was done using visual programming software, in which the user drags and places in an orderly fashion, to see if the pictures are correct, depicting the desired operations to be made by the robot.
- Initially, the general course objectives were announced to all students (Anagnostakis & Michailides 2006). Next, in each class a different teaching approach was implemented. Teaching took place once a week for three hours in a laboratory.
- At a later point the students were divided into two groups (study and control), with their initiative, groups made up of 2-4 individuals. The first class consisted of 5 groups of three and 1 group of four. While the second class consisted of 4 groups of three and 2 of two individuals. The placement of the students in each class was done without them knowing which the study group was, and which the control group was.
- In the control group class teaching was conducted as in the previous semester (Anagnostakis & Michailides 2007). In this class, teaching was based on package instructions, in which once the students completed an exercise (construction and programming), they continue to the next level. The challenge included robot construction which was to write on a piece of paper a specific word and the criteria was the speed of writing (the least required time) in correlation with the quality of letters written.
- In the study group class the students worked more autonomously. In the weekly three hour class meetings, students decided on their own (or with the

instructor assistance if absolutely is needed) the steps to be taken. The steps included the installation of the software programming for the correct operation of the robots, and the construction of a robot following the manual's instructions. The manner, in which the groups worked, was determined to a great degree, by the members of each group, described in a publication (Margetousaki, Anagnostakis & Michailides, 2008). All the groups in the first part of the course, had to assemble and program the robot – vehicle, which had to remain on the road, by-passing any hindrances (diagram 1). In the second part of the course, instead of an examination and the construction of a robot, students had to design, organize, materialize, and evaluate a lesson in a school (for the 5^{th} or 6^{th} grade). The objective was to introduce to the school students, basic concepts on robot construction and operations.

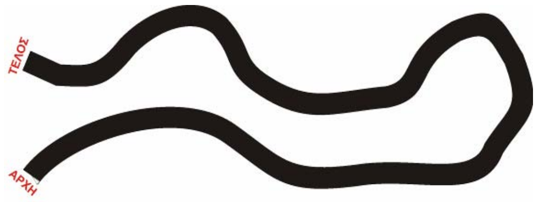

Diagram 1 An example of the course the vehicle - robot had to follow; getting around any hindrances on the way.

- Students in both classes completed a work calendar and similar questionnaires relevant to teaching-learning content of weekly laboratories. Teaching was conducted by one of the authors of this publication, while another observed class meetings and kept records. At the end of the semester the students from both classes completed the same questionnaire, which was also administered the previous semester (Anagnostakis & Michailides 2007). Furthermore, a meeting took place with everyone involved present, where comments and experiences were expressed as to the general nature of the course.

3. Results

In **Table 1** are the anonymous students' responses to the questionnaire completed at the end of the course. Please note the study group consisted of only females. We consider it a coincidence because from a previous study conducted, no preference differentiation was noticed due to gender. The total female population in Department is 80% and in the laboratory course is 74%. The students chose the course based on the day it was offered and were not aware of the study or control groups.

Table 1: Questionnaire Responses

	Participants		Responses	
	Class Total	**Females**	**Total**	**Females**
Control group	**16**	*9*	**14**	*8*
Study group	**19**	*19*	**14**	*14*
Total	**35**	*26*	**28**	*22*

Following is a synoptic overview of the questionnaire responses.

3.1. Write briefly your impressions of the course. Everyone had a positive opinion for the course even though several, specifically those from the study group class, thought of it as 'hard because it required a lot of thought but was worth it'. Indicative phrases used: *creative, original, different from other courses, boring in the beginning but amazing at the end….*

3.2. What do you think you will remember in 5 years time from this course? In the study group class, everyone mentioned the teaching which took place. In the control group, they mentioned the robot they designed and constructed for the competition. Both groups mentioned the cooperation and the attempts they made to fix a robot that worked.

3.3. Mention up to two of the best characteristics the course had. All students mentioned creativity (in the study group this is mentioned more). Mention was made also in the satisfaction gained from construction (8 times), the construction itself (3 times) new experience-indicative phrases: *it was an awesome experience- I got to know myself in a new situation* (6 times), the demand for imagination and innovation (5 times) and cooperation (6 times).

3.4. Mention the course's worse characteristics. Almost everyone considered the course demanding or difficult *('it was necessary to come another time to complete our assignment).* The constant assessment and the work calendar (~1 in 2).

3.5. Was the teaching guidance good? 27 Yes, 1 No (from the control group).

3.6. Mention up to two of the best guidance characteristics. The beneficial comments (key words from their expressions) assistance in deductive reasoning (almost all). Indicatively: *the instructors guided us, advised, encouraged, allowed us to put our minds to work and be creative and constant guidance ('we asked whatever we wanted without any hesitation and the instructors were close to us').*

3.7. Mention the teaching guidance worse characteristics. Lack of encouragement (5 times), too many students (7 times), organization (3 control group), nothing (4 times), insufficient guidance or discouragement (3 control group). In the rest 10 questionnaires the question was not answered.

3.8. Was there cooperation in your group? Yes 25, No 3 (study group).

3.9. Mention up to two of the best functional characteristics your group had. Cooperation (11 study group, 9 control group), task allocation (3 control group), or no task allocation (3 study group, 2 control group). One questionnaire from study group not answered.

3.10. Mention the worse functional characteristics your group had. None (4 study group, 5 control group), no cooperation (6 study group, 1 control group), had disagreements (4 study group, 1 control group), role confusion and unequal participation (1 control group).

3.11. What was the course missing? Did not answer (1 study group, 5 control group), nothing (3 from each group), Greek texts and video (2 from each group), recess and meals (7 study group), additional help (1 study group, 2 control group), more computers, time, teaching in schools (1 control group).

3.12. What was not needed in the course? Observations and weekly presentations (8 study group, 6 control group), nothing – no answer (6 study group, 5 control group), programming (the robot) (3 control group).

3.13. What issues do you think were needed to be covered but were not? Did not answer (5 study group, 7 control group), nothing (6 study group, 3 control group), theory (1 study group), teaching at schools (1 control group), programming the robot (2 control group), study of other robot cases (2 study group, 1 control group).

3.14. Would you recommend this course to other students? Yes 28, No 0 times.

3.15. Would you take another similar course? Yes 26, No 2 (study group).

3.16. Do you think you could teach a similar class in school? Yes 23, No 5 (2 study group, 3 control group).

3.17. Support your answer to the previous question. No, because I do not know the subject well enough and it's difficult. Yes, because I did it (study group). Yes, because I know the subject (control group). Materials and infrastructure required.

3.18. Make any additional remarks related to the course, if you wish. 20 did not answer (9 study groups, 11 control group). No comment (1 study group), different and original (2 study group), *I have a question: from all the questionnaires, you produce statistics and percentages!!* (1 control group), *many questions, the pictures were not needed* (1 study group), *the most interesting course I have taken* (1 control group), *I did not expect to like it so much at the end* (1 control group), *what I will remember is the emotions I felt.... JOY, CREATIVITY, SURPRISE, ENTHUSIASM, DISAPPOINTMENT* (1 control group).

4. Comments

The students attended the course without absence; it is worth noting, in similar courses when practical work began (construction, measurements, field research,…) absence up to 50% is observed. Though, those who remained in class, achieved a high grade; 25% higher (Michaelides, 1998; Margetousaki & Michaelides, 2004). The same high grades were achieved now. Generally, the answers in the questionnaire, as presented in 3.1 – 3.18 are identical to those given in the previous semester (identical to control group) (Anagnostakis & Michailides 2007). There appears to be no significant difference between the students in the study and control groups pertaining to their impressions of the course with the exception of a tendency in the study group, using stronger positive expressions to describe the course.

From the instructors' observations and reports, the students' work calendars, as well as the discussion which followed at the end of the course, it is evident that:

- The students in the control group showed to develop construction dexterities earlier (3^{rd} – 4^{th} week) than the students in the study group (5^{th} – 6^{th} week).
- The students in the study group focused on their answers, more so than the students in the control group; the characteristic of the problem solving situations was emphasized at the same time as a positive as well as negative.
- In the study group class cooperation among the members of each group seems to be equal in rank, without distinct allocation of duties (assemblers - programmers) (Margetousaki, Anagnostakis & Michaelides, 2008).
- Teaching in schools conducted by each group in the study class covered the basic objective of introducing students to basic concepts and operation principles of robots, according to the reports and comments made by the course instructors.
- The teaching approach the students were taught by, they copied to a great degree and followed it while teaching in schools. Teaching time lasted two hours (one hour in one class). Therefore, when they posed problems pertaining to construction-assembling or programming, they reached the corresponding solutions in relatively short time after their attempt.In most cases they simply described what and why everything was done.
- As to the ramming, in several instances it was covered by the preparation of cards with command pictures in visual programming language, which the students put in the order they thought correct. This way they had a sense of the program they were constructing and could detect and correct error faster.

With partial exceptions in one teaching, for which we specifically report, from all the other teachings in schools it is evident that:

- The students showed vivid enthusiasm which lasted throughout the teaching period. The majority of students asked for a repetition of classes in order to go beyond the mere display.
- Students in most cases could not focus and sit still for a long period. Most of them moved between the assembly and programming groups, not waiting for the completion of the task. This is expected in this age, that's why experienced instructors, who are involved in student teaching organize teaching time in short units (5-10 minutes each).
- The students with the exception mentioned below, showed equal interest in involvement in the assembling and programming of robots. They also showed great ingenuity and originality by pointing out instances where a robot could be constructed.
- In one teaching session it was observed that the students were unable or had lost their interest for robot assembling – construction and focused their interest on the "esthetically pretty" computer (Mac lab top), in which the software was installed, without focusing on the aims of the lesson. According to the students' report who taught the class, the school is considered degraded and lacked necessary equipment, audio visual devices and the space in general gave the sense of desertion. The majority of the student population were immigrant children from countries from the former Eastern Europe, who did not have any previous experience in toys similar to Lego© whereas, computers were more familiar.

- From the indicative assessment it seems that the students, to a great extent, were acquainted with basic concepts and robot function principles and characteristic instances of implementations.

In the students' views, pertaining to the lesson, a contradiction is evident. While all of them considered the lesson "worth while" and would recommend it to others, they considered as its worst characteristic the weekly reports and the time required (even though, a percentage overlapped from the previous, considers the latter at the same time one of its best characteristics). This observation is under examination. It could mean that the work load for this class is a lot. However, we did not observe any of the groups in the laboratory for more than three hours beyond the three hour weekly teaching sessions. Taking for granted that 1-2 hours of individualized study per teaching hour is considered an acceptable work load for a university course, students' observations could simply mean they compare this course with other courses, which are considered easier or because the equipment used was only in the laboratory and work at home was not feasible. Another possible interpretation could be the fact that the course's format requires weekly preparation on time and could not be left summative for the examination period. In favor of the latter we can take the students' discontent for the weekly reports, which however, are considered necessary for the particular reaching approach, as a means of checking the work calendar assignments.

All in all, the teaching approach of "self teaching" in the study group class, achieved the aims and objectives (acquaintance with the concept and robot operations, the development of complex cognitive skills and abilities and, acquaintance with modern technology) of the course, equally well (if not better) with the more traditional approach in the control group class, while it helped the materialization of the teaching in school.

5. Conclusions

When computers first entered schools there was great scepticism and many reactions. Instead of a systematic and holistic study of how to achieve the goals of compulsory education, discussion was limited –as a rule- on personal opinions, fragmented experimental studies for partial themes, while the introduction was limited to technical knowledge as an additional subject instead of the formation of an educational environment suitable to the goals and objectives of each school level.

Today, there is the Laboratory of Educational Robotics, whose introduction to schools, specifically in schools of compulsory education, is, with the proper and systematic preparation, feasible as an educational environment, or as an activity of developing dexterities of practical construction problem solving skills.

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