Training mixed groups of teachers and students in educational robotics using the studio pedagogical model.

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Abstract

This paper presents an introductory robotics training program for teachers and students. The training adopted the "studio" pedagogical model. Studio model stems from formal education in architecture and is consistent to constructionism theory and learning by design model. It is an intuitive model of learning in cases where the trainees apply complex skills from many disciplines and arts. In the paper, first a basic theoretical background of the pedagogical model is presented and it is explained how this method conforms to the requirements of educational robotics and the conditions of this specific training program where students and teachers are simultaneously trained. Following, the detailed description of the program implementation illustrates its design. Then, the evaluation results, which come from teachers and students, are reported. Finally the program results are discussed and remarks are summarised. The contribution of the study concerns mainly the experimental pedagogical verification of the studio approach to educational robotics training as a fruitful learning model consistent to constructionism.

Keywords

Educational robotics, professional development, studio pedagogical model

Introduction

It is common belief that educational robotics provide rich learning opportunities. The application of robotics in education require expensive materials, learning resources, support and training for teachers, so usually it is applied occasionally in the vast majority of schools. Recently more and more attempts of exploitation of Educational robotics in Greek schools are documented. Indicative projects of this kind concern preschool (Fesakis & Tasoula, 2006), primary (Anagnostakis & Makrakis, 2010; Tsovolas & Komis 2010) and secondary education (Fragou, et al, 2010). In addition there are systematic efforts to develop training curriculums in robotics, for teachers. These curriculums include courses in University departments of primary education for pre-service teachers (Anagnostakis, et al, 2008) and professional development programs for secondary education in service teachers (e.g. the TERECoP project Alimisis et al, 2010; Alimisis, 2009; Papanikolaou, et al, 2007), which provide important conclusions and experience for every new attempt in teachers' training for robotics. The existing programs usually underpin the use of workshop and hands-on approaches for training. This paper presents an innovative program for professional development (for teachers) and training (for students and teachers) in educational robotics which uses the studio pedagogical model. The program is short-term (lasts 12 hours), introductory, and aims to familiarise students and teachers (simultaneously) with basic concepts

and techniques of educational robotics. The studio pedagogical approach adopts the model of "architectonic studio" (Tripp 1994; Clinton & Rieber 2010), it is consistent to constructionism learning theory and supports the "hands on" approach suggested by the bibliography. In addition the studio pedagogical model utilizes the idea of apprenticeship of less experienced "technicians" to experienced "masters" (the students/teachers trainees and trainers correspondingly in our case) in basic aspects of robotics (e.g. construction, programming and composition).

The paper presents first the studio pedagogical model, continues with the training implementation then reports the assessment of the program by the participated teachers and the students and finally discusses the results and summarises the remarks.

The Studio Pedagogical model

The studio model is common in the formal architecture education where students are often involved in learning oriented to design. The method originates from the architectural workshops (studios) of renaissance, where many craftsmen and artisans were working on teams under the supervision and guidance of experienced masters to create different artefacts in painting, sculpture etc. The apprentice craftsman in architectural studios could work in several art teams, in the same studio, under the direction of corresponding masters until he/she finally choose the art which best fits to his/her capabilities.

The choice of studio model is based on the fact that the construction of a new robot is mainly a design process, which requires the application of several sets of skills, concepts and capabilities which correspond to different arts and disciplines (e.g. design and mechanical construction of the device, programming, interaction with the environment with sensors and signal processing, knowledge from the application field, physics, and mathematics). The studio professional development model is documented in the international bibliography (Tripp 1994; Clinton & Rieber 2010) to such an extent and abstraction level as to be applicable in situations other than its origination. The studio pedagogical model except from the schools of Architecture is also proposed for other fields which deal with technology design like software engineering and educational design.

According to studio model the training is taking place in a laboratory (the studio) equipped with tools, materials, design models, plans and experienced masters (as trainers and directors). In the studio the trainees can practice individually and collaboratively on authentic projects for external "customers". The working hours are flexibly defined in the sense that the students can practice and study both on scheduled sessions or whenever they choose to.

Description of the training program

The training program called "We create Robots in Rhodes" was organised by the Municipality of Rhodes city in Greece. The target group were students and teachers from local primary and secondary schools. Its aim was the familiarisation of students and teachers to educational robotics in order to create groups to participate in the Greek robotics contest organised by WROHellas, as national qualifier to the World Robotics Olympiad. The scientific coordination of the program has been entrusted to the Learning Technology and Education Engineering (LTEE) Laboratory of the Department of Pre-school Education and Educational Design of University of the Aegean. The project coordinators and designers were Prof. Angelique Dimitrakopoulou, and Dr. Georgios Fessakis. The course was supported by the non-profit organisation WRO-Hellas (official organiser of the Hellenic Educational Robotic Contest), the county of Dodecanese and the Technical Chamber of Greece/Department of Rhodes.

Organisation of training

The Stavros Niarchos Foundation (SNF) donated to the Municipality of Rhodes 50 LEGO Mindstorms (code 9797) robotics sets for the needs of the training. Every participating school received 2 robotic sets for practice during hours out of the training programme. The donation also included 4 robotic sets for the needs of the trainers, an interactive white board and a video projector. The training was designed to take place in four computer laboratories in which 6 trainers could support 120 people (students and teachers) maximum. Finally 15 schools and 78 trainees (20 teachers and 58 students) participated after an invitation of Municipality of Rhodes to the local Schools forming 20 groups of 3-5 persons each that could (as a team) participate in the contest. Each team was composed by one or two teachers and 2-4 students. The 20 teams were divided in 3 computer labs equipped with fast internet connection, video projector and 6-7 working tables (Fig 1). Each team also had a LEGO Mindstorms robotic set and a laptop. Finally, 2 trainers were available in each computer lab.

Figure 1. Typical computer lab of thetraining

Figure 2. Teams during the training

The schedule of the training

The training was held in four meetings, of four hours duration each (10:00-13:00) every Saturday from 20 Feb 2010 throughout 13 Mar 2010. In the first 3 meetings both students and teachers (Fig. 2) participated. Students and teachers were trained in educational robotics. The participants

had no or very limited previous experience. In addition the teachers were trained to take the role of the future coach of his/her students' team. In the last meeting only teachers participated to learn about the contest organisation details and procedures. So the net duration of the training on robotics was 12 hours. During the scheduled training the groups of students and their teachers-coaches were engaged in learning activities in order to get familiar to educational robotics under the supervision of experienced computer science teachers who had the role of master craftsmen.

For the authenticity of the project the role of the "customer" had been assigned to the Greek Educational Robotic Contest, which required from the students to design and construct a robot for a specific mission. The students could study and practice on the scheduled meetings of the training as well as in time of their choice using sets of robotics and accompanying learning material that had been provided by to their schools.

The brief syllabus of the program follows:

1st meeting: a) Introduction to robotics; b) Introduction to materials, sensors and microprocessor; c) Construction of first robot, which was common for all teams; d) Programming of the first robot without the use of computer.

2nd meeting: a) Completion of the construction of the first robot; b) Programming the robot with LEGO Mindstorm programming environment

3rd meeting: a) Solution of basic robotics' problem (e.g. line follower, maze, obstacle avoidance); b) Creating our own robot; c) Evaluation of the training by students

4th meeting: a) Answering teachers' questions; b) Informing teachers about the Greek Educational Robotic Contest.; c) Evaluation of the training by the teachers

For the training needs, learning activities were designed and developed using resources from the LEGO sets, and available in the bibliography. The teachers and the students were also guided to various internet sites related to robotics in order to be able to continue learning after the training.

Training Evaluation

For the training program assessment three different questionnaires were designed, for the teachers, the students and the trainers correspondingly. Illustrative results and their interpretations from these questionnaires are presented in this section.

Teachers' assessment of the program

Fig. 3 summarizes teachers' answers on queries Q1-Q5 concerning their satisfaction of the training program. From the answers we can support that the teachers are fairly satisfied from the training in general (Q1) and most of them (13/19) are completely satisfied both in general and according to students' learning outcome (Q2). The teachers show satisfaction with the LEGO robotic sets (Q3) and with the trainers (Q4). Finally, they are fairly satisfied with the computer labs (Q5) despite the fact that they suggest bigger labs. The Q6 asked if the teachers would participate again in robotics training. Most teachers (16/19) answered that they would participate again, 2 didn't answer and only one teacher answered negatively.
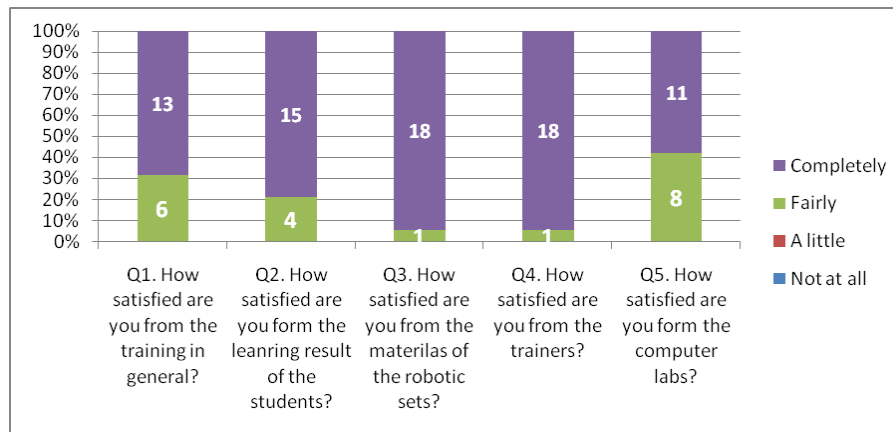
Figure 3. Teachers' answers in Q1-5

Q7. Is educational robotics developmentally appropriate for students?

In Q7 teachers were asked to state whether they find educational robotics developmentally appropriate for their students. Teachers asked to think if it is too easy (so the students will lose their interest) or too difficult (so the students will be discouraged), and furthermore whether it has any learning interest. Most teachers (15/19) answer 'yes' and assume robotics developmentally appropriate using arguments like:

- *Robotics could help to achieve goals of Computer Science, Mathematics and Physics curriculums.*
- *Robotics encourages creativity, inventiveness and self-acting.*
- *Robotics support experimental learning, students initiative, creativity and critical thinking*
- *It is not difficult for the students*

Two teachers (T12 and T15) notice that the robot programming needs a special approach for the younger children

Q8. Comment the appropriateness of training method

In Q8 teachers comment on the appropriateness of the studio model. The teachers recognize that the studio model was student-centred, experiential, collaborative, exploratory, and problem solving based. They also stated that the method is appropriate for students. Furthermore, the separation between robotics construction training from their programming (as different arts) is a good choice (T12). Finally there are proposals like:

- *The participants in each laboratory must be at the same level of education (T3)*
- *The trained students should become trainers assistants on future trainings (T4)*

Q10. What was the most difficult part of the training for you and the students?

The main difficulties that are stated by the teachers are

- The programming (T4, T6, T7, T8, T13, T14).
- The design-construction of a new robot (without instructions) (T15, T16, T18).
- The assembly – construction of the physical parts of the robots. (T1, T10, T16, T18)
- The short available time for practice (T19)
- The design of the robot for the contest (T2, T15)

Q11. What was the most attractive part for you and the students?

Attractive elements of the program as they were mentioned by the teachers, except of the challenge of programming and constructing robots, include: the collaborative and peer form of teachers and students participation, the effectiveness of the method (goals achievement), the joy of the practice, the creative character of the activities, the challenge of discovery, the simplified approach of robotics which usually requires long studies, and the authenticity of robotics curriculum applied.

Q12. What are the aspects of the training that you and your children didn't like?

As negative points of the training, the teachers mark the small size of the labs, the short duration and the small number of available construction materials.

Summarizing teachers developed and expressed quite positive views for the training program and the studio method. Furthermore teachers propose improvements and extensions for future versions of the program.

Students' assessment of the program

In this section students' assessment and ideas after the training are presented. Students answered a questionnaire of closed and open questions the most significant results of which are following. Fig. 4, summarizes the answers of students to questions Q1-Q5 which concern their satisfaction of fundamental aspects of the program. The students are satisfied from the training in general (Q1) and from the constructions of the robots (Q2). They are also satisfied both from the trainers (Q4) and from the robotics material (Q3). Some of them (8/50) are little satisfied from the labs that held the training. We concluded from their answers and from the answers of the teachers that the available space per group should be greater and maybe a specially designed working table could improve the experience even more.
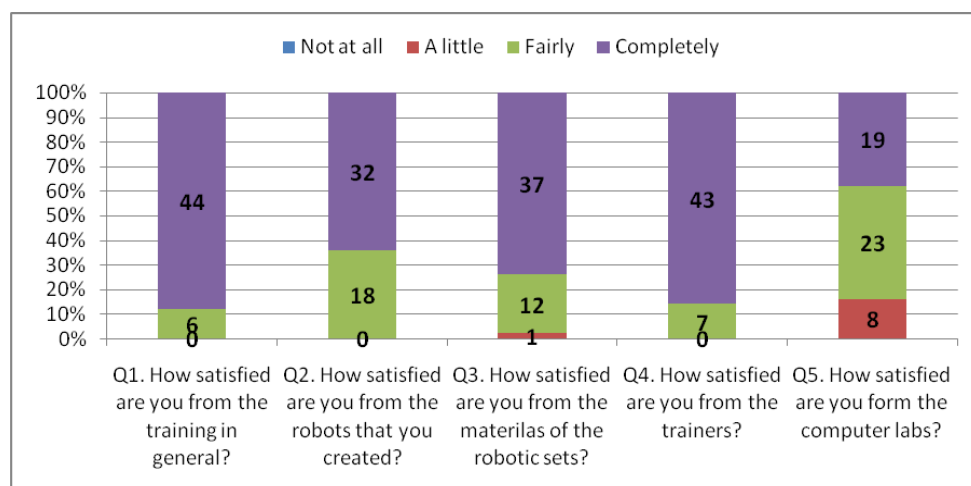

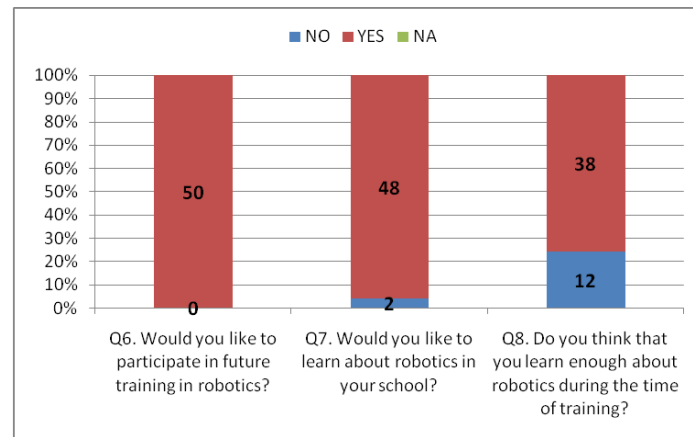*Figure 4. Students' answers in Q1-5*

Figure 5. Students' answers in Q6-8

Fig. 5 summarizes students' views about their participation in the program. All students want to participate in future robotics training and the overwhelming majority of them want to learn robotics at school. In Q8, 12 of 50 students answered that they do not know enough about robotics; it seems that the introductory training created more questions than those it answered.

In the following, the answers of the students in open questions are categorized and presented to inquiry their ideas about robotics after the program.

Q9. What I learned...

Most students (41/50) answered the obvious: *Construction and Programming of robot.* On the other hand there are four answers which refer to collaboration skills and other abilities like: *working with patience, not to give up trying, improvising,* which are indicative to learning load of working with robotics

Q10. What I liked most...

Most students reports the construction (19/50) or/and programming (12/50). It seems constructing is more pleasurable than programming, for children. There are also 7 enthusiastic students who like everything. Especially we notice references to

- Robotics parts and materials, sensors, and motors.
- Characteristics of the learning design of the program: *the videos, the problems that were solved by the robot, the creation of our own designed robot the last Saturday of the training.*
- Qualitative social and emotional characteristics of the activities: *Collaboration, the whole experience.*

Q11. What I did not like...

The students did not like the lack of space of the labs (7/50), the foreign language of the software (1/50), the programming difficulties (3/50), the robots construction part (1/50), and the material of the set (2/50). Most of the students (28/50) answered "nothing".

Q12 What made it difficult to me ...

The students found difficulties in construction and/or programming while 3 of them refer that they couldn't find ideas for their own robot in the last meeting (Table 1).

Frequencies	Answers
19	Nothing
13	Construction
12	Programming
3	Ideas for my robot
2	NA
1	The material because it was unbowed

Table 1. Q12 What made it difficult to me...

Q17. I would like to construct a robot to…

The students' imagination as it is expressed by the answers (most answers are in Table 2) is impressive. Most students like robots with human abilities e.g. to study for them, to do the housework and to be absolved from time-cost and boring tasks in general. Also, some of them like a robot to be a friend, an assistant, surgeon, rescuer and older people assistant. Furthermore, we have proposals concerning animals e.g. dog, scorpion, and turtle. In the next category we have mechanisms performing difficult or useful works, which sometimes are artistic (play music, paint), sometimes are utilitarian (garbage collector, gardener) and sometimes just perform a single job (climbing stairs, walking on walls, solving the rubric cube). A student said that he would construct a robot with his friends, which means that he believes that the robot construction is entertaining.

Frequencies	Answers
8	Study
6	Do the housework
4	Abstract
4	Walks
3	Assistant
2	Surgeon
2	Solves the Rubik Cube
2	Plays music instruments
2	Scorpio
2	Friend
1	Climbing stairs
1	Gasoline vehicle with electricity
1	Older people assistant
1	Huge human
1	Rescuer
1	Floats on water, avoids obstacles
1	Paints shapes
1	Wins the contest
1	Garbage collector
1	Ecologist
1	Plays with a ball
1	Gardener

Table 2. Q17 I would like to construct a robot to…

Q14. A robot looks like...

Exploring the students' ideas about robots we see (Table 3) metaphors like humans-assistants-friends featured by anthropomorphic characteristics which are rather expected because of their existing mental representations (mainly from movies). Furthermore we observe the ideas of a car or an animal. Finally, there are ideas like a machine, small creatures, even UFO.

Frequencies	Answers
25	Human – Assistant – Friend
10	Car
9	Animal (Dog, Scorpio, Turtle)
4	NA
1	Remote control
1	Anything
1	Engine
1	Small creatures
1	As you can imagine them
1	Spaceship

Table 3. Q14 A robot looks like

Summary

As we can see from the answers in questionnaires, we can state that pedagogical method "Studio" which was used in the program had fairly positive results both to teachers and students. This means that the training was fairly successful. The teachers are very satisfied from all sides except from the available space in the labs where the training took place. It is very important that the majority of them assume that the learning result of their students was quite satisfactory, confirming our choice for the pedagogical method, and would like to participate in future trainings. The students also evaluate the training positively and just few of them point out the small size of the labs. It is very encouraging the finding that the students learnt not only to construct and to program a robot but also to collaborate, to work with patient, to improvise and not to give up trying.

The success of the studio model relies on the fact that the educational robotics requires skills for design and synthesis of complex constructions combining several arts and disciplines. Obviously the development of such skills requires a pedagogical method which utilizes experiential and empirical learning and exploits the apprenticeship to more capable peers and collaborators. Using the studio model students and teachers had the opportunity to get familiar with a diverse set of skills in a rapid and more intuitive manner than a linear training program that would present every relevant aspect in a sequential mode without the scaffolding of the trainers.

All the above are sealed by the successful participation of four groups in the Greek Robot Contest, which had been organized by the WRO Hellas the summer of 2010. More specifically, the team of 2nd Vocational Lyceum of Rhodes with trainer Mr. Dimitrios Kladogenis won the first place in its category. The group represented Greece in the International Robotics Contest which held in Filipinas (Philippines) in November of 2010 and took the 15th place among 48 teams from all over the world.

The educational robotics as a course which combines the science with the mechanics, the ICT and

the creative design deserves to be studied more from the view of its educational applications. The training team plans to invest in the experience to promote more the educational applications of robotics. Furthermore, the pedagogical method studio can be applied to other subjects in future, like the pedagogical training of the teachers and the educational design with ICT.

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