# A Constructivist Methodology for Teacher Training in Educational Robotics: the TERECoP Course in Greece through Trainees' Eyes

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## Abstract

*This paper presents a constructivist methodology for teacher training in robotic technology and its implementation within the framework of a teacher training course. The methodology in question is aimed at keeping in line with the proposed use of robotics as a tool of constructivist teaching and learning and is meant to train teachers in the very way in which they will be asked to train their pupils in school classes. The evaluation of the above methodology is seen through the eyes of the trainees, as reflected in the questionnaires they filled in and the diary they kept. The evaluation leads to the conclusion that the teachers were positive about the planning of the course, as it gave them the chance to pass from their initial role of a trainee in robotics to that of a teacher planning activities in robotics for their pupils.*

## 1. Introduction

During the last few years, robotics is being introduced in school education, from kindergarten to high secondary school, either as an interdisciplinary, project-based learning activity or focused on school subjects, such as Science, Maths, Informatics and Technology [1]. The TERECoP project (Teacher Education on Robotics-Enhanced Constructivist Pedagogical Methods) involving 8 educational institutions from 6 European countries (www.terecop.eu) is being activated in the field of educational robotics aimed at (among other goals) the training of future and in-service teachers in the effective introduction and use of robotics in school classes [2].

This paper gives a brief description of the theoretical context and of the teacher training methodology proposed by the TERECoP project based on constructivist principles, presents the implementation of the methodology within the framework of a pilot teacher training course and ends with the evaluation of the methodology by the trainees themselves and with some conclusions drawn from those evaluations.

## 2. Theoretical context: robotics and constructionism in education

In the TERECoP project, a constructivist view for learning is adopted, whereby robotic technologies are not seen as mere tools, but rather as potential vehicles of new ways of thinking about teaching, learning and education at large [3].

Learners, in a constructivist learning environment are invited to work on experiments and authentic problem-solving with selective use of available resources according to their own interests, research and learning strategies. They seek solutions to real world problems, based on a technological framework meant to engage students' curiosity and initiate motivation [4].

The LEGO Mindstorms NXT system (http://www.legomindstorms.com) attempts to partner technology with the ideas of constructivism. It offers building materials, sensors connecting a robot with the external environment and programming software with a simple graphical interface intended for the creation of robot behaviours.

## 3. The TERECoP training methodology

As part of the TERECoP activities we developed a pilot training course for in-service and student-teachers. The aim of the course was to enable trainees to understand the pedagogical perspectives of educational robotics and to develop robotic activities within the constructivist approach of teaching.

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Therefore, we designed a course for adult trainees incorporating the most important aspects of the constructivist approach.

The idea of "learning by design", which is central in the constructivist pedagogy, was firstly introduced by Resnick [5]. In our training course we supported this idea through the project-based learning approach. Learning tasks of the course were organized as small or large scale projects that encouraged trainees to design and develop their own products. Themes of the projects were either ill-defined by the trainer or freely chosen by the trainees. In that way, trainees had the opportunity to express their own ideas and to select themes close to their professional needs and personal interests. Therefore, trainees were 'personally connected' with their projects, a fact that forms an additional requirement for invaluable creative work and effective learning [6].

The active involvement of the trainees in all the parts of the course was the second important aspect. A teacher training course can contribute to the professional development of teachers, by forming relations between teachers' existing experiences and the proposed new educational technologies. So, from the beginning of the course, trainees were encouraged to express themselves and to participate in all activities of the course through discussions in small groups, presentations in plenary sessions and publications on their e-class. In this way, current ideas, beliefs and attitudes of the participants were made explicit and evaluated within the constructivist approach.

Throughout the course, all trainees were working on their learning tasks independently. The role of the trainer was to facilitate the learning process by creating an interesting and stimulating learning environment: giving feedback at regular intervals, raising interesting questions, guiding the research concerned and synthesizing ideas. Trainees, on the other hand, were responsible for their work; they could follow their own path in their exploration and could develop their own ideas. They were supported in their work by useful resources, such as worksheets, representative examples and user guides.

Finally, the constructivist learning environment was based on cooperation. Social interaction within small groups generates a fruitful learning environment, where ideas are expressed, discussed and developed. So, most of the learning tasks were performed by trainees working in small groups.

## 4. The implementation of the methodology

The training course was held at the premises of the School of Pedagogical and Technological Education (ASPETE) in Athens, and organized in 5 face-to-face meetings that each one lasted for 6 teaching hours, during 3 Fridays/Saturdays afternoons. 4 trainers and 23 trainees participated in the course: 4 teachers of primary education, 10 of secondary education and 9 candidate teachers. In particular, during the 5 meetings, trainees were actively engaged in activities working in teams with peers as described below:

1st meeting: After 'breaking the ice' introductions, the trainees were invited to discuss their own expectations, opinions, suggestions and ideas first in groups and then in the plenary in order to decide together with the trainers a 'didactic contract'. After that the trainees worked in groups studying a specific section of a paper on constructivist learning, presented briefly the abstract to the whole class and the trainer commented on the presentations emphasizing on the use of robotic technologies as constructivist leaning tool.

2nd meeting: This meeting focused on the introduction of the materials included in the Lego Mindstorms Education NXT kit, and robots' assembly. Trainees constructed a car robot with two motors using instructions included in the user guide. The session finished with a discussion resulting on a set of criteria for evaluating robotic constructions.

3rd meeting: Trainees worked in groups on several activities designed to introduce specific programming instructions and functionalities of the programming environment. Appropriate worksheets had been developed for each particular activity to allow groups to work autonomously.

4th meeting: Trainees initially reflected on the methodology proposed by the TERECoP project for developing robotics-enhanced projects for students. Then they worked on a real project designed according to that methodology, they discussed their experiences and concluded to evaluation criteria for well-designed robotics-enhanced projects. Finally each group designed a project outline using the same methodology.

5th meeting: Students had one kit at their disposal for two weeks in order to develop their own project based on the methodology for designing robotics-enhanced activities proposed in the course. So, during this final session, trainees presented their own projects [7] and received feedback. Finally, trainees completed an evaluation questionnaire about the course (methodology, organisation, content, e-class, learning experience and integration of robotics in the school reality) and they participated in a group interview.

An e-class had been developed and maintained through the course (a) to provide trainees with

resources (course content, worksheets, presentations) and on-line support, and (b) to promote a sense of community among the members of the class (trainers and trainees) providing opportunities for communication/collaboration and resources sharing during and beyond the face to face meetings.

## 5. Evaluation of the methodology through trainees' eyes

20 of the 23 trainees participated in the final evaluation at the end of the course. As to their specialization, there were 2 Mathematicians, 1 Physicist, 5 Engineers, 8 Informatics teachers and 4 Primary School teachers (10 males, 10 females). The trainees were volunteers in the course (some of them work as teacher trainers) and only 2 of them had a previous experience in educational robotics. For the evaluation of the course, a series of tools were used. This paper presents and discusses some of the evaluations made by the trainees themselves regarding the educational methodology applied in the course, as recorded in the diaries that they kept on the e-class right after the end of each meeting and their responses to the written questionnaire which was given to them at the end of the course.

### 5.1 The diaries

A selection of typical statements from the diaries kept by the six groups of trainees concerning the course training methodology is shown in table 1.

**Table 1. Typical statements from the diaries kept by each of the 6 groups of trainees**

| *"What was the best thing that happened to you today?"* | *"What was the worst thing that happened to you today?"* |
|---|---|
| - We experienced the joy of creation, we built the robot up and it proved operational.<br>- We managed to complete the exercise and to park the "bus" | - Very little practical application, quite a lot of writing on the *Word*. |
| - The whole process of the robot construction and its ensuing programming was pleasant and creative<br>- The construction process and that of experimentation with the scenario of spiral | - We did not manage to make our robot move along a square …<br>- There should have been more time available for experimentation and testing… |
| - When the robot moved along a square on the floor we rejoiced like young children!<br>- The activity where we tried to discover the function of the variables within a program<br>- Our group managed to propose a number of ideas for implementation in class | - The activities at the project's assembly stage "The bus route". The assembly stage was impossible to be implemented and we were compelled to talk theoretically. |
| - The exploration of the robot. It was great fun!<br>- The collective effort (one section by each group) in constructing the bus. It was a very interesting and very well organized approach. | |
| - The discussion of the construction ideas and the experiment with the power-speed relation<br>- The result of the commands given to the cat robot to "miaow" | - Little time available for practical work<br>- The hurried process regarding proposals for teaching strategies: it did not convince us as to its targets and what is looking for |
| - When we collectively constructed the robot, set it in operation and carried out the activities<br>- Our contact with Lego has begun to attract our attention and we are already anticipating the learning scenarios to be included in our classes.<br>- Instructing our bus-robot to stop when it encounters an obstacle | - When the lesson was over!<br>- Difficulty in the exploration and understanding of the variables<br>- When there was not adequate time available for the completion of activities, learning was senseless<br>- The seminar should have lasted longer |

### 5.2 The questionnaire

Responses of the trainees to a selection of questions included in the questionnaire are presented below.

**A.** *What do you think of the participation / involvement of the trainees in the course?*

The trainees, overall, describe their participation / involvement in the course as very or quite active. Their responses focus on their active involvement in the activities concerning robotic constructions and their programming, on team works, as well as on the debates that took place in the course room and via the e-class. The appraisal of their participation in the "theoretical" part of the course was, likewise, positive. ("We took

an active part even in the theoretical part, where our active involvement was encouraged").

**B.** *What do you think of the proportion that existed between practical activities (by the trainees) and the presentations (by the trainers)?*

75 % think that there had been proper balance between practical activities and presentations. They think that the presentations were necessary for the support of the practical activities ("The presentations had appropriate duration at critical points in the progress of works and their completion"). 25% ask for more practical activities: "A greater involvement in activities and their exploration would have generated great interest"; "In general terms, there had been balance, but I would have liked more weight to have been given to the practical activities, since they are more attractive. Besides, we are "full" of theoretical presentations".

**C.** *What do you think of the support provided by the trainers?*

The trainees describe the support provided by the trainers as very (95%) or quite (5%) satisfactory: "They supported ideas, encouraged efforts, proposed solutions". They describe their support as "discrete and when there was need for it". They describe, likewise, the support provided via the e-class as satisfactory.

**D.** *What do you think of the duration of the course?*

30% consider the program's duration as satisfactory, while 70% would have liked more hours spent on it. Some of them explain that it was their first contact with the programmable robotic constructions and needed more time to become more familiar with them, others would have liked more time as they wanted to do more things ("to swim in deeper water", "there were things we did not have time to do, although they were interesting, e.g. collection of data from the environment"). Some others think that they needed more time for the preparation of their assembly works and that through longer engagement in the subject matter in the classroom they could have produced better projects.

**E.** *State any difficulties that you encountered during the course.*

They mention difficulties in respect of programming activities ("certain *Switches* seemed 'too heavy' for me"; "I would have liked more engagement and experimentation activity in the programming field for the development of the necessary skills"), difficulties in respect of cooperation between teams outside seminar when dealing with the assembly side of their group project, difficulties with the material available: they would have liked more Lego blocks available and one set per each trainee.

**F.** *What do you think of the training material (work sheets, software examples, presentations etc.)*

75% consider as very useful and 25% as quite useful the training material given to them. They explain that the material "gave ideas and outlets regarding the pedagogical approach, as well as regarding the educational utilization…"; "with effective subject sequence…"; "it succeeded in involving us under normal conditions in the rationale and philosophy of both, the Lego Mindstorms and the logic of robotics in education". They considered as positive the fact that "there had been presentation of a comprehensive work, which enabled them to study all its stages". Some of them would have liked more material "for additional stimuli…" or for "homework".

**G.** *What in the course seemed interesting to you and worth-while using in class with your students?*

They mention the teaching means used, such as the e-class and the worksheets, the training method and the teaching approach based on the cooperation of teams. Especially appreciated was the cooperation between teams in processing the theoretical texts, which took place at the first meeting; it was found useful for their own work in their capacity as trainers of other teachers.

**H.** *Evaluate each one of the parts of the program, stated in the table shown below, by marking them as follows:* ***6****= excellent,* ***5****= very good,* ***4****=satisfactory,* ***3****= moderate,* ***2****= inefficient* ***1****= very inefficient*

The average marking was as follows (table 2):

**Table 2. Evaluation marks for the course**

| Part of the course | mark |
|---|---|
| Educational content | 5.60 |
| Educational method | 5.45 |
| Support by the trainers | 5.80 |
| Educational material | 5.40 |
| Educational results | 5.25 |
| Electronic class | 5.00 |

## 6. Discussion and conclusions

From the diaries kept by the trainees it appears that their statements as to "the best thing that happened to them" during the meeting involved focus on the practical activities, the creation of their own engineering structures and their programming. ("We experienced the joy of creation, we built it up and it was operational"). It appears, indeed, that they enjoyed their work ("When the robot moved along a square on the laboratory floor we rejoiced like young children"). Already from the initial activities some of them started thinking of scenarios for inclusion of similar activities in their school.

Conversely, among "the worst things that happened to them" they mention cases of "very little practical work and quite a lot of writing on the Word» and, in some cases, lack of time required for the completion of their work. Their preference for practical work and their negative attitude towards "theoretical presentation" is also clear from the fact that they recorded among their negative experiences the case where, because of lack of adequate time, their practical work was substituted for theoretical discussion.

Their positive experiences include, inter alias, the project-based learning method that they followed in their work and the exploration, experimentation and creation features included in that method, although some of the groups found that the proposal formulation process in respect of teaching strategies, which the trainees were asked for, was "hurried" and non-convincing and that the implementation of the project "bus route" stage was not feasible.

From the questionnaire responses it appears that the training methodology of the course ensured their active participation, that there was fair balance between practical activities on the part of trainees and presentations on the part of the trainers although some of them request even more practical activities and fewer presentations. They seem happy with the support and encouragement given to them by the trainers, while most of them asked for longer duration of the course. The difficulties mentioned by them are focused on robot programming elements (switches, variables) and the cooperation beyond the course, given that each group had only one Lego Mindstorms set at its disposal.

They evaluate the teaching materials given to them as very useful. They state that the above materials as well as the training methodology followed in the course are worth applying either in their school classes with their pupils or in training fellow teachers (by those who work as trainers of teachers). The quantitative evaluations for the course range between very good to excellent (Table 3) regarding all the aspects of the course that were evaluated.

Lastly, for the course improvement they propose even more emphasis to the construction work, additional and more complex examples of robotics activities, greater activation of the groups, increased sharing of ideas and projects between trainees via the internet and expansion of that communication to reach teachers of other European countries cooperating in the TERECoP project. The above evaluations made by the trainees were confirmed by the group interview that took place at the end of the course [7].

As an epilogue, we shall use the following very pointed statement made by one of the trainees, as, in our view, it describes in a concise manner the success of the methodology we applied: "What I enjoyed most of all in the seminar was its planning. I liked the fact that we initially functioned as learners in the activities proposed, so that we crossed over to the other side, as a start, and, subsequently, we undertook the role of a teacher and came to the level of activity planning. I think that this kind of planning provided a quite comprehensive image of the usefulness and utilization possibilities of robotics in education".

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