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Teaching Educational Robotics (*)

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This work is based on published papers – see slide 5

Affordable & Efficient Science Teacher In-service Training

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Contemporary Societies:

- Are based on Science developments (but not always on Science)
- Are dependent on advances in Technology.

Consequently,

STL - Science and Technology Literacy is:

- Critical for the welfare,
- Necessary to further development,

of the society,

STL is also a prerequisite for the existence of Democracy.

In Democracy, citizens participate actively on decision making process on their own and not as followers of a charismatic leader or being under the shepherd. As the decisions (regulations, resolutions … the legislation in general) are increasingly dependent on the advances in Science and Technology, active participation in democracy means that citizens should be S&T literate having also the cognitive skills permitting to make decisions on issues they are not experts. Model formation and scientific inquiry enhance such skills and they should constitute integral part of teaching, especially of Science teaching. Within this context, the effective Science and Technology teaching may be considered as a 'democratic right', a right to democracy. Otherwise, Science will be confused with religion as in the 'dark' years of Middle ages or as in some parts of the world now, e.g. see for the U.S.A. in http://www.ncseweb.org/ (visited at 29-Jun-2007) where education in Science, especially the theory of evolution, has been made a legal issue contesting religious dogma).

- **Due to the Rapid developments:**
  - **Science and Technology Literacy has to be achieved through education**
  - **Misconceptions and alternate conceptions are more frequent in S&T**
- **Primary Education emerges as a very important factor because:**
  - **It is the longest component of the compulsory education**
  - **Students' age where character formation and cognitive skill development.**
  - **Misconceptions at this age are difficult to correct later.**
- **Literacy in Information and Communication Technologies (ICT) constitutes a priority in developed and in developing societies.**

Training for the Science and Technology Teacher:

- **Subject matter knowledge should not be factual,**
- **Issues should be in a form to be used in school with little adaptation**
- **Adopted teaching approach:**
  - **practice towards teachers self-training on the subject**
  - **project assignments seem to be an obvious choice,**
  - **inquiry and problem solving should be encompassed**
- **Use of digital information as the one available on the Internet**

Cross thematic - Interdisciplinary teaching approaches are necessary and more effective

Educational Robotics present an appropriate teaching environment:

- **Familiarization to New Technologies, methods and materials,**
- **Development of problem solving skills,**
  through the design and implementation of a Robot artefact,
- **Promotion of cooperative learning through the assignment of group tasks,**
- **Better understanding of Science and Technology basics**
  through the construction of the robot artefacts.

- **Robots are present in everyday applications**
  electric kitchens and laundries, car engines, phones, …
- **Many relevant Laboratory kits**
- **We used the Lego© Mindstorms©**
- **May be considered as the evolution of the LOGO environment.**

This work is based on the following publications:

Simos Anagnostakis, P. G. Michaelides,

'Laboratory of Educational Robotics'
An undergraduate course for Primary Education Teacher - Students

Paper presented at the HSci 2006 - 3rd International Conference on Hands-on Science, 4th - 9th September, 2006, Braga, Portugal, proceedings published by University of Minho, pp 329-334.

http://www.hsci.info/hsci2006/index.html

Simos Anagnostakis, P. G. Michaelides,

Results from an undergraduate test teaching course on Robotics to Primary Education Teacher – Students

Paper presented at the HSci 2007 - 4th International Conference on Hands-on Science, 23 - 27 July 2007, Ponta Delgada, Azores, Portugal, proceedings published by University of Minho, pp 3-9.

http://www.hsci.info/hsci2007.html

S. Anagnostakis, A. Margetousaki, P. G. Michaelides ,

The Feasibility of Educational Robotics to Primary Schools

Paper presented at the 4th PanHellenic Conference on the Didactics of Informatics, University of Patras, Patras 28-30 March 2008, proceedings pp. 243-252 (in Greek)

http://www.ecedu.upatras.gr/didinfo/

Course Design

Objectives:

- Understanding the basic concepts of robots,
- Familiarization with robot programming,
- Apprehension of the possibilities and limitations of robots,
- Development of problem solving skills.

Syllabus:

- Familiarization with the material Lego Mindstorms©,
- Construction of simple robots under guidance,
- Construction of a robot on their own,
- Design and implementation of (part of a) smart house,

Results of a Test-Teaching – course organization:

an undergraduate course at the spring semester of 2007

as an optional choice in the area of Informatics in Education of the Department for Primary Education of The University of Crete.

- **addressing students at the 5th or higher semester of their studies**

  graduates of this Department are qualified to be appointed as teachers in the primary school.
- **the course was delivered by the authors of this work** who also made observations ('action – research').
- **in course announcement:**
  - **no formal prerequisite knowledge was demanded from course candidates**
  - **Computer literacy extending to computer programming → potential advantage**
- **course planned for 16 students in one class**

  due to its experimental character and the limited number of robot kits.
- **course chosen by 26 students – all were accepted:**
  - **two classes were formed**
  - **in groups of 3 to 4 students** instead of the planned two students per group, due to the limited number of robot kits.
  - **expected to be compensated by students' drop-out**

  large in similar subjects in the Mathematics, Science and Technology area of the curriculum.
- **most of the students:**
  - **had already completed their basic courses in Science and in Methodology of Teaching.**
  - **they were computer literate**
- **drop-out rate was zero** we comment on it later.

Results of a Test-Teaching – course organization (continued):

- The course was delivered in intervals of three teaching hours per week for 13 weeks.
- Students were free to use the laboratory for more hours - almost all they exploited this
  to prepare or study for their assigned tasks
- The equipment used was the LEGO© Mindstorms (see Picture 1)
  easier purchase – students were familiar with Lego parts from their infancy.
- There were two different versions of the robot processor units.
- The programming was made on PC's with Windows XP or Mac's with OS X.
- The Robolab© Software supplied by LEGO was used an icon based programming language.
- The program was then transferred through the infrared link to the robot units.

Picture 1. Some of the equipment used

Results of a Test-Teaching – course delivery:

First 3 weeks, all class together:

- Introduction to concepts related to robots and robot programming,
- Examples of robots used already in different applications were given,
- Students were encouraged to propose possible applications of robots in other areas also,
- Familiarisation with available equipment,
- Teaching of common techniques of robot programming.

- Practice experience with the equipment (robot kits),
- Task assignment within the groups (designer, programmer, constructor …)
- Construction (assembly) of simple robots from the examples given in the manuals.

Next 4 weeks (weeks 4 - 7), in groups (formed on their own initiative):

- Construction (assembly) of simple robots from the examples given in the manuals (continued),
- Clarifying explanation of the logic of the respective robots was demanded,
- Students were asked for alternative approaches,
- Design and assembly of a robot of their own for a specific task

  i.e. to construct a robot that could transfer objects from a place to another one - contest.
- Introduction to the concept of a smart home.

  i.e. to construct a robot that could transfer objects from a place to another o.

Results of a Test-Teaching – course delivery (continued):

Next 3 weeks (weeks 8-10), in groups:

- Construction and testing of their own robot,
- Contest,
- Introduction to the concept of 'Smart Home' and its components

water heater and central heating, internal-external house lights, the garage gate, refrigerator with food stock monitoring, … .

Next 2 weeks (weeks 11-12), in groups:

- Construction (assembly) of a prototype of a component of 'Smart Home'.

i.e. to construct a robot that could transfer objects from a place to another one - contest.

Last (week 13), in class - assessment:

- Through an 'anonymous' questionnaire during the last week.
- Brain storming type discussion commenting on the course

after the questionnaire was completed by the students.

Students were free to use the laboratory for more hours - almost all exploited this opportunity

- Supervisor always present during the laboratory use by the students.
- Providing guidance during the first weeks
- To help and advice, if asked, afterwards,

- Students submitted a short weekly report (one per group) on their work.
- They get also involved (voluntarily) to the translation of selected parts of the manuals.

Results of a Test-Teaching – Teachers' observations:

No students' drop-out:

- **Remarkable – usually 30%-50% when practice work starts,**
  students have a rather negative attitude towards Mathematics, Science and Technology.
- **Achieved high marks (at the upper 25%)** similar to other courses for continuing students,
  perceived (?) as a positive change towards Science and Technology.

None of the students had any previous experience with computer programming:

- **They managed quite well** using the supplied software with the (intuitive) icon based robot programming language.
- **They had to work in the laboratory outside the teaching hours**
  in order to get experience with the programming, a fact that added to their workload significantly
- **They worked on a trial and error basis** without resorting to the manuals (even if they were translated),
- **When failed, they asked for help** with self-ironic comments on their abilities.

indication (?) of increased interest, of self-esteem and of a friendly teaching environment

further supported by the fact that the teaching proceedings of the course were known widely arousing the curiosity of other people (students, technicians, even outsiders) and many times there were outside observers during the teaching.

Groupwork:

- **Work within the groups was mostly on an equal basis with peer discussions**
  even at the 2 groups where there was an evident domination of activities by one of its members, all members were active
- **Sometimes lengthy discussions leading to disputes** especially during the first weeks,
- **In 3 groups the advice to assign responsibilities was implemented literally**
  and it seemed to be another source of dispute.

Results of a Test-Teaching – Teachers' observations (continued):

No apparent differentiation in task responsibilities between girls and boys

- Girls were equally involved in constructions with gears, wheels, etc

  although this is considered, to some extent at least, a male occupation.

Course objectives attained at least at the students' group level

- successful assembly and operation of the robot under guidance (end of the 7th week),
- successful design and construction of a robot of their own (end of the 9th week - very little guidance),
- participation to the contest (end of the 9th),

A 'by product' of the course:

- the experience from the attempt to form a Greek – English dictionary of terms related to robots and robot programming
- someone was uploading a term
- others (or the same person) were proposing translation and explanation.
- Links to relevant web sites was also indicated.

Results of a Test-Teaching – Teachers' observations (continued):

On the final task requested, namely that of a component of a 'smart home':

- all groups made a rough analysis of one of the components, but,
- at the end all groups choose to construct a rather simple household item
  - a mechanism counting entries and exits
    to be used as a Gate counting persons in a place or as a post-box indicating new mail,
  - a solar device following the sun
    to be used on household solar devices used in Greece to increase their efficiency,
  - a toy producing soap bubbles activated by light or movement to be used with children,
  - automatic irrigation control system to be used in watering flowers on the owners absence,
  - a lighting device activated by detection of sound or movement
    to be used in corridors, outside of the house areas, etc.

It seems that the time allotted to this activity was not sufficient, one or two more weeks were missing.

However the main objective was achieved by all groups more or less successfully:

- detect application areas for a robot work and 'invent' an implementation.
- increased self esteem towards Science and Technology

all were keen to have their pictures and videos from the contest published on the web site of the Department.

Results of a Test-Teaching – Students' response:

- 24 students (8 boys, 16 girls) registered to the course
- 22 (7 boys, 15 girls) answered questionnaires were received.
- Percentages: boys – girls equal male – female primary school teachers.

- In the following we present the answers we received from the students.
- The answers are grouped.
- Mostly open type questions – students' answers included many issues.
- Students included, mostly, more than one characteristic in their answers.
- The answers are still being analysed.

Results of a Test-Teaching – Students' response (continued):

1.-Write briefly your impressions from the course. Students found the course:

- interesting (very interesting, most interesting),
- creative,
- different from the courses they were used to,
- a nice experience,
- useful.

2.-What you think you will remember from this course 5 years from now.

- The team work,
- A pleasant course,
- The construction,
- Our efforts and time devoted to solve construction – programming problems,
- The contest,
- The new ideas (1 answer),
- Nothing (1 answer).

Results of a Test-Teaching – Students' response (continued):

3.-Write up to 2 of the best characteristics of the course.

- teamwork,
- useful,
- creative – intelligence – originality (in 18 out of the 22 questionnaires),
- pleasant,
- practice work.

4.-Write the worst characteristics of the course.

- A lot time (10 out of 22),
- not enough materials,
- no manuals in Greek,
- not detailed guidance (4 out of 22),
- sending reports every week was tiresome,

- 'no bad or worst characteristics it simply requires more time than other courses' -1 answer.

Results of a Test-Teaching – Students' response (continued):

5.-The guidance was sufficient? (Yes/No). 22 out of 22 Yes.

6.-Write up to two of the best characteristics of the guidance.

- helpful remarks,
- always present,
- patience,
- Socratic Method.

7.-Write the worst characteristics of the guidance.

- no detailed guidance (we had to complete the task ourselves),
- no praise on our efforts,
- left to follow wrong threads without early warning.

Results of a Test-Teaching – Students' response (continued):

8.-Was there cooperation in the group? (Yes/No). 20 Yes, 2 No.

9.-Write up to two of the best characteristic in your group.

- effectiveness,
- enthusiasm,
- teamwork,
- mutual assistance,
- understanding,
- none (in the 2 that said No to the previous question).

10.-Write the worst characteristics in your group.

- none (7 out of the 22),
- disputes,
- trying to impose decisions,
- fixed responsibilities (in one case),
- many persons (in one case).
- No reply from one of the students who answered no cooperation
- no teamwork-disputes-trying to impose decisions-no respect to other opinions'. from the other student who answered no cooperation

Results of a Test-Teaching – Students' response (continued):

11.-What was missing from this course?

- more detailed guidance,
- manuals in Greek,
- shortage for some materials,
- a more spacious laboratory,
- links with other departments teaching this course to exchange ideas (in 1 out of the 22).

12.-What was surplus in this course?

- nothing (in 9 out of the 22),
- the weekly reports,
- the demands to improve our artefacts,
- the theory (in 2 out of the 22).

13.-What issues should also cover this course?

- none (in 7 out of the 22),
- more theory including the context and its role in pedagogy,
- use of other equipment also,
- smart home should be a common project for the whole class (in 2 out of the 22),
- 'Coffee and snacks (!)' (in 1 out of the 22).

Results of a Test-Teaching – Students' response (continued):

14.-Would you recommend this course to your fellow-students? (Yes/No). 22 Yes.

15.-Would you choose another course of a similar type? (Yes/No). 21 Yes, 1 no reply.

16.-Do you think you could teach such a subject in school? (Yes/No). 15 Yes, 7 No.

17.-Justify your previous answer.

Yes because:

- it is not so difficult – it is within the abilities of the students and mine (in 12 of the 15 yes).
- Yes provided there exist the infrastructure parts, equipment, computers, laboratory, time … (in 3),
- Yes provided that there is adequate preparation and more training (in 1 of the 15 yes).

No because:

- with the current situation in (Greek) schools there is no infrastructure,
- it is outside the culture, it is very demanding, it is time consuming, it is very difficult,
- I do not learned the programming.

Results of a Test-Teaching – Students' response (continued):

18.-Add any other relevant comments you think appropriate. (10 replies).

- amusing, interesting,
- I think you should have encouraged us more as it was totally unknown to us,
- at the beginning I was afraid but I do not regret choosing it – it was hard work but worthy,
- it was the most amusing course we had – in its negative are your criticism giving the impression you did not value our efforts,
- I liked the teaching approach, the friendly within the group and with the teachers – in general the nicer and most interesting seminar,
- it should have only two persons per group,
- next time more parts (in 3 of the 10 replies),
- constructive, original. Good to be introduced in schools,
- constructive and creative for school students who could learn in parallel Science, Mathematics and Information Technology.

Some Comments (analysis still going on):

The course objectives have been met successfully:

- Students became familiar with the concept of robot and its possible uses.
- Students learned the basic principles of assembling and programming a robot.
- Students learned to locate areas where a robot may be used and plan its implementation.
- Students had the opportunity to develop problem solving skills.

This is supported also from the, negative for some students, comments of them, that they missed detailed guidance or that they were left to follow wrong threads (see 4-7 above) more detailed guidance.

On the management and delivery of the course problems were located:

- expected due to the initially planned test teaching on a small scale - they are under study.
- limited number of kits – more than large number of students per group

  ➔ purchase of more kits on a variety of component parts

  however, more groups ➔ increased teachers' workload
- no manuals in Greek ➔ translation, however:
  - not a problem actually,
  - preference of a trial and error approach or of teachers' help (even if manuals in Greek existed).

Some Comments (analysis still going on) (continued):

On the management and delivery of the course problems were located (continued):

- the course needs a lot of time ➔ some thinking required

➔ students' workload is high as already the students have indicated

However:

- normal workload 1 teaching hour corresponds to 1-2 hours of homework (a reasonable assumption)
- no student worked in the Laboratory for more than three hours

in excess of the three teaching hours per week.

Consequently, the higher workload may be subjective feeling, due to:

- homework had to be done in the Laboratory during work hours

not in home at any convenient hour

lending the robot kits to students could be a remedy at an increase to the course's logistics ➔

- homework had to be done in time for the next teaching session

while in other courses this could possibly be left for a later time – even till the examinations

a view supported by the students' comments on the weekly reports monitoring homework study

Some Comments (analysis still going on) (continued):

Balance between theoretical context – practice work – school curriculum:

- closer connection between the robot assembly techniques and underlying Science concepts,
- balanced level of detail for the guidance on the actual practice work is essential,
- the sophistication required on the robots constructed should balance the time available.

Students liked the course. They judged it as:

- interesting, creative, different (with a positive meaning) from other courses,
- 'it took us a lot of time but it was worthy' as one student explicitly wrote.

Even some of the negative aspects they were provoked by the questionnaire's structure to write may be considered as positive remarks, for example students' comments about the worst characteristics of the guidance.

No differentiation between girls and boys:

- similar achievements and marks obtained,
- similar involvement as 'programmers' or constructors' or otherwise,
- No apparent sex differentiation on the groups the students had formed,

they included all girls or all boys as well as mixed groups.

Some Comments (analysis still going on) (continued):

The self-esteem of the students towards Science and Technology has increased:

- **they feel confident that they could manage a similar teaching in school**

  with themselves as teachers.

An explicit objective of the course that may explain, to some extent, the origin of the (negatively perceived) comment 'no praise on our efforts'.

Relation to the school curriculum:

- **students have, in general, the opinion a similar course can be incorporated into schools**

  even most of the negative answers accept this possibility on the fulfilment of some conditions.

Although this cannot be considered as 'experts' opinion' it is noticeable moreover as the students who had attended the course had some school experience through their school practice courses.

A second Test-Teaching – winder semester of 2007:

Course organization and delivery was, in general, the same as previously with the following adaptations:

Students were divided in 2 distinct groups.

In the 1st group (control group) the teaching was the same as in the previous semester
The competition was to make a robot able to follow a certain path as depicted in Figure 1.

In the 2nd group (test group) instead of the final task (a robot made on the students' own initiative) students were assigned the task: Design and deliver a teaching on Educational robotics to primary school (Grades 5th or 6th i.e. ages 11 or 12).

Figure 1. Sample path to follow by the robot constructed in the 2nd part avoiding possible obstacles.

A second Test-Teaching – winter semester of 2007 (continued):

The objective of this test teaching was to study the feasibility of introducing Educational Robotics to Primary school.

Specifically:

- **To check if teachers could be (self-) trained to the basics of Educational robotics to the extent that they could organize similar courses in their schools**

  As a consequence in the test group the guidance was limited to answering specific questions only – usually the answer was in the form of another question that could lead students.

- **To check if a course on educational robotics is within the abilities of school students.**

Students selected their group on the base of their other course they were enrolled and without knowing the different content.

At the end of the course students were asked to answer the same questionnaire as in the previous test teaching

A second Test-Teaching – winter semester of 2007 - Results:

In general, the assessment of the course was similar to the findings presented earlier.

There were no statistically significant deviations between the test group, the control group and the students in the previous test teaching.

Only a tendency for the test group to use more positive expressions for the course.

Based on observations during the course, on the students' logbooks and their reports and on the discussion that followed the conclusion of the course the following observations were made:

- **Students in the control group developed dexterities of robot construction somewhat earlier than the students in the test group although at the end both reached the same level.**
- **Students in study group emphasize more the problem solving characteristics of the course as a positive and as a negative (requires more effort) aspect of the course.**
- **Cooperation within the test group was on a more on a par and without evident role assignment**

(all consequences of the different guidance).

A second Test-Teaching – winter semester of 2007 – Results (continued):

7 primary school teachings were organized, each by a different group of 2 to 3 student from the test group.

The following were observed:

- **The teaching achieved its objective of familiarization of the school students with the basic concepts of robots - functioning and design.**

  according to the reports from the students in the test group and their tutors

- **The design of the teaching was, more or less, on the same trend as the teaching the students in the test group were exposed to.**
- **Teaching was done in two teaching hours (1 in one case). As a consequence, the time left to school students for thinking and retrospection on the problems posed to them was limited and tutor guidance was extensively used with verbal explanations.**
- **To cope with the (very) limited skills of school students on computer programming cards with the icons of the iconistic robot programming language were cut on cardboard. School students placed them on a table in the order they thought correct and then they tested it – a method of quick programming and debugging.**

A second Test-Teaching – winter semester of 2007 – Results (continued):

With one exception for which we comment later, in all the teachings in school:

- **The teaching achieved its objective of familiarization of the school students with the basic concepts of robots - functioning and design.**

according to the reports from the students in the test group and their tutors

School students:

- **Show an interest vivid throughout the teaching. Almost all asked to repeat the teaching and advance more into robotics.**
- **In most cases, school students were active and continuously changed roles (constructing the robot body – programming - …), an expected observation for this age (maximum time of focused attention in the order of 10-15 minutes, a fact that has to be taken into account).**
- **With the one exception mentioned already, all school students show an interest for the construction and for the programming of the robots. They suggested novel ideas to cope with problems of construction and/or programming. They also suggested robots with a variety of functions.**

A second Test-Teaching – winter semester of 2007 – Results (continued):

With one exception for which we comment later, in all the teachings in school:

- **The teaching achieved its objective of familiarization of the school students with the basic concepts of robots - functioning and design.**

according to the reports from the students in the test group and their tutors

In one of the teachings in schools:

- **School students lost their interest in the construction of the robot artefact and concentrated, almost exclusively, on the computer (a nice portable Mac) used for the robot programming.**
- **It was the school with only an adequate success of the teaching objectives.**

Further study showed that in this school, almost all the school students were immigrants from former east European countries with no previous experience at all on Lego type activities, while computers were more familiar to them.

A second Test-Teaching – winter semester of 2007 – Results (continued):

In the final assessment of the course:

- **All the students consider the course as very worthwhile,**
- **They would recommend the course to their fellow students,**
- **They would enrol in courses of a similar type.**

However:

- **They consider it as a difficult course**
- **The obligation of keeping a logbook and submitting reports on a regular weekly basis was considered as a very good or a very bad characteristic of the course.**

This phenomenal inconsistency is under investigation.

It may mean that the students were satisfied by their successful efforts but that, in comparison with other courses the course on the robotics was more demanding. The strict time schedule imposed together with the requirement to be in the laboratory for their 'homework' may also contribute to the impression of a difficult course.

A second Test-Teaching – winter semester of 2007 – Results (continued):

In conclusion:

- **The teaching approach on 'self-teaching' in the test group achieved the planned objectives:**
  - **Familiarisation with the concepts of robot and robot programming,**
  - **Development of complex cognitive skills like problem solving,**
  - **Development of skill for self personal development,**
  - **Facilitating the design of a corresponding teaching in school**

<u>As a result:</u>

The introduction of educational robotics in schools as a regular school subject seems feasible.

A second Test-Teaching – winter semester of 2007 – Results (continued):

Epilogue:

Computers in schools caused a lot of controversies, nevertheless, when used appropriately, they are a useful tool for the cognitive development and learning.

Today, the Laboratory of Educational Robotics may provide a similar but more powerful learning environment for the development of complex cognitive skills and practical dexterities

Currently, we exploit this idea with a 'deprived' school in a rural area of Crete, where school students are indifferent to school subjects and activities.

Our first results are very encouraging – students start to change their attitudes towards schooling

More:

The test teaching was successful

We plan to include this course into the undergraduate curriculum on a regular basis.

in connection with actual school teaching.

A view from The University of Crete campus at Rethimno - Thank you