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Results from an undergraduate test teaching course on Robotics to Primary Education Teacher - Students^(*)

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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**

Interthematic - 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.**

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>

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.

Conclusion:

The test teaching was successful

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

possibly in connection with actual school teaching.



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