The Hands-on Science Network[4] will be maintained in the form of an International Association (www.hsci.info) and will keep growing enlarging its membership and the impact of its activities and proposals in our schools and societies...

inducing a better science education ...
in favour of a sustainable development ...
… towards a brighter future of humankind ...

3. Conclusion

World' sustainable development both in economical and social terms strengthening the democracy and social cohesion in our societies with high levels of human development in respect to the United Nations chart of human rights should be a goal of all countries and of each one of us.

The importance of Science, both the pursuit of knowledge and the search for practical uses of scientific knowledge, is widely recognised at all levels in modern societies. A strong and enlarged scientific literacy is fundamental to the development of science and technology but also to a democratic citizenship.

4. Acknowledgements

As coordinator and chair of the Hands-on Science Network, the author would like to acknowledge the enthusiastic participation of all member of H-Sci in this effort of improvement of Science and Science Education.

5. References

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Results from an Undergraduate Test Teaching Course on Robotics to Primary Education Teacher – Students

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Abstract. In a previous work we have presented the design of an undergraduate course with the title 'Laboratory of Educational Robotics'. Its syllabus includes the assembly and (simple) programming of different modules towards the construction of a robot performing specified (simple) tasks. The course objectives include the familiarization with the notion of robots and the development of cognitive skills. The course was designed within the general context of increasing the Science and Technology Literacy, a crucial factor for the modern, technology based societies. In this work we present results obtained after a test teaching during the first semester of 2007 to undergraduate students of the Department for Primary Education of The University of Crete.

Keywords. Laboratory, Educational Robotics, Robolab, Primary Education.

1. Introduction

It is increasingly accepted that an effective Science and Technology Education may be achieved by an interdisciplinary teaching approach within a constructionismic context. In this sense, Educational Robotics is especially useful. On this basis we have presented in a previous work the design of an undergraduate course with the title 'Laboratory of Educational Robotics' [1]. Its syllabus includes the assembly and (simple) programming of different modules towards the construction of a robot performing specified (simple) tasks. The course objectives include the familiarization with the notion of robots and the development of cognitive skills. The course was designed within the general context of increasing the Science and Technology Literacy, a crucial factor for the modern, technology based societies. Pursuing the objective to construct (or assemble) a robot, students may develop complex cognitive and problem solving skills. They are also presented with real problem situations in which, trying e.g. to chose and manipulate the appropriate sensors or to incorporate movement to the robot, they are helped to a better understanding of basic

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concepts in Physics. In this work we present results from a first time test teaching of this designed course to the undergraduate students of the Department for Primary Education of The University of Crete.

2. Course Delivery

The course was included within the undergraduate program of courses 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. 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. It addressed students on the 5th or greater semester. Most of the students addressed have already completed their basic courses in Science and in Methodology of Teaching. In their majority they are computer literate. In the announcement of the course it was stated that no formal prerequisite knowledge was demanded from those choosing to attend the course, although computer literacy extending to familiarization with simple computer programming would be an advantage. Due to its experimental teaching as a laboratory course and taking into account the available equipment (number of robot kits) the course was planned for 16 students at a maximum in one class. The course was chosen by 26 students. Instead of selecting between them, it was decided to enrol all the students, forming two separate classes in groups of 3 to 4 students instead of the 2 persons per group planned initially. This arrangement was made partly in order to compensate for possible drop-out that is significant in the Mathematics, Science and Technology area of the curriculum partly as a limitation imposed by the number of available robot kits. The drop-out rate was zero a fact we comment on later.

The course was delivered in intervals of three teaching hours per week for 13 weeks. Students however were free to use the laboratory for more hours, if they wanted to prepare or study for their assigned tasks. The equipment used was the LEGO© Mindstorms (see Figure 1) because their purchase was easier. They had the added advantage that the LEGO parts are familiar to most (almost all) of the students. 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 using the Robolab© Software supplied by LEGO, an icon based programming language. The program was then transferred through the infrared link to the robot units.

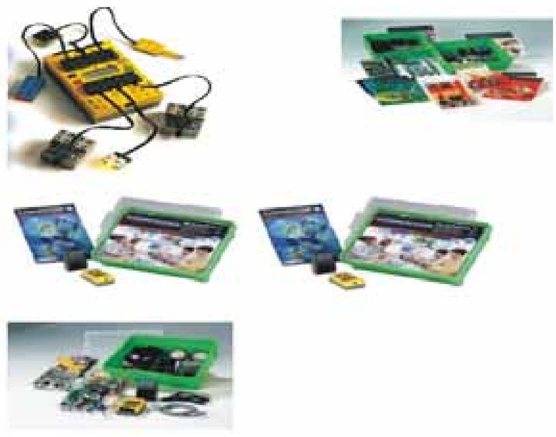

Figure 1. Some of the equipment used

The teaching was organized as follows:

- During the first 3 weeks students were introduced to the concepts related to the robots and the robot programming. Examples of robots used already in different applications were given and students were encouraged to propose possible applications of robots in other areas also. During these same weeks the available equipment was available to the students. They were taught its use so as to become familiar with common techniques of robot programming.
- During these first 3 weeks all the students were in one class. During the next weeks, students were working in groups formed by them. Every group had its own Lego Mindstorms set to use throughout the course. Students were advised to assign between the members of every group the responsibilities for the design, for the assembly, for the programming, etc.
- During the next 4 weeks students were assigned the task of constructing a specific robot from the examples given on the manuals. The manuals were in English, a factor causing difficulties to the students. A clarifying explanation of the logic of the respective robot programs was demanded from the student as an indication of their understanding. Alternatively they could make their own programming to perform the same (or more) tasks. In parallel, students were introduced to design and assemble 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. To make it more interesting a contest was setup where the student made robots will compete, in pairs, to clear their area of a number of ping-pong balls transferring them to the opponent's area.

 ISBN 978-989-95336-1-5

- The next 3 weeks were dedicated to the construction and testing of the robot. At the end the contest was made. During the same period, students were introduced to the concept of 'smart home' with the objective of study, design and implement, in a model way, a specific component of a 'smart home' The students were asked to identify such components and possible ways of introducing appropriately made robots. Students were encouraged to identify components of their own although, as a help, the following components were indicated and analyzed to some extend:
  - the operation of water heater and of central heating,
  - the interior – exterior house illumination in relation with the presence – absence of the residence or with other conditions,
  - the operation of the garage gate,
- The next 2 weeks were dedicated to the implementation and the presentation of the 'smart home' components that every group of the students had chosen.
- During all times of laboratory work a supervisor was always present to guide, during the first weeks, or to help and provide advice if asked, afterwards. Specific parts of the manuals. Referring to the assembly and some techniques on achieving specific results, were also translated into Greek and made available to the students.
- Students were also requested to submit a short weekly report (one per group) on their work.
- During the last week, through an anonymous questionnaire with open type questions students were asked to express their opinion on specific aspects of the course [2]. The remaining time after the completion of the questionnaire, was dedicated to a free brain storming type discussion commenting on the course experience.

3. Teachers' observations

All the students attended the course without any drop-out. This is a rather remarkable outcome for this type of course at the specific Department where the majority of students have a rather negative attitude towards Mathematics, Science and Technology. In previous courses, when the actual practice work (constructions, experimentation, field research …) commenced there was a significant drop-out rate (up to 50%). The remaining students however, all were achieving high marks. High marks, on the upper 25% range, were also achieved in this course.

None of the students had any previous experience with computer programming but they managed quite well using the supplied software with the (intuitive) icon based robot programming language. Quite often, however, the students 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. A rather worth noticing observation was that, mostly, students were trying to correct their programming or their assembling without resorting to the manuals (even if they were translated into Greek) but by trial and error techniques. This may be perceived as an indication of increased interest and self-esteem about their abilities to succeed on the subject. If their attempts failed, students were asking advice from the instructors quite often with humorous comments an indication of a friendly teaching environment.

The zero drop-out rate for this course despite the increased students' workload together with the high marks achieved may be perceived as a positive change of the students' attitudes towards Science and Technology. This explanation is 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.

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 discussions on what to do were lengthy and lead to disputes, especially during the first weeks. In three groups, the advice to assign responsibilities was taken literally and it seemed to be another source of dispute.

There was 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.

Judging from the results obtained at the end of the 7th, 9th and 11th weeks, students had attained the objectives of the course at least at the group level. They assembled successfully and put into an efficient operation the robot under guidance (end of the 7th week). They all succeeded to construct a robot of their own (with very little guidance) and participate to the contest (end of the 9th week). 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 indicated to them but at the end all groups choose to construct a rather simple household item – accessory (automatic light equipment, a toy activated when light or movement was detected, …) [3]. It seems that the time allotted to this activity was not sufficient, one or two more weeks were missing. However the main objective to detect application areas for a robot work and 'invent' an implementation was achieved by all groups more or less successfully. Their self esteem towards Science and Technology seems to have increased – all were keen to have their pictures and small videos from the contest published on the web site of the Department.

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

4. Students' questionnaire

From the 24 students (8 boys, 16 girls) registered to the course 22 (7 boys, 15 girls) answered questionnaires were received. The percentages boys – girls is the same to the percentages of male – female primary school teachers.

In the following we present the answers we received from the students. The answers are grouped. With the exceptions indicated, answers in the open type questions occurred more than once. Students included, mostly, more than one characteristic in their answers. The answers are still being analysed.

4-1. **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.

4-2. **What you think you will remember from this course 5 years from now**. 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).

4-3. **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

4-4. **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 characteristic, it simply requires more time than other courses' (1 answer).

4-5. **The guidance was sufficient?** (Yes/No). 22 out of 22 Yes.

4-6. **Write up to two of the best characteristics of the guidance**. Helpful remarks, always present, patience and Socratic Method, ideas.

4-7. **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.

4-8. **Was there cooperation in the group?** (Yes/No). 20 Yes – 2 No.

4-9. **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).

4-10. **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 while the second mentioned 'no teamwork-disputes-trying to impose decisions-no respect to other opinions'.

4-11. **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).

4-12. **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).

4-13. **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, snacks (!)' (in 1 out of the 22).

4-14. **Would you recommend this course to your fellow-students?** (Yes/No). 22 Yes, 0 No

4-15. **Would you choose another course of a similar type?** (Yes/No). 21 Yes, 0 No, 1 no reply.

4-16. **Do you think you could teach such a subject in school?** (Yes/No). 15 Yes, 7 No

4-17. **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

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infrastructure i.e. parts, equipment, computers, laboratory and time (in 3 of the 15 yes), 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.

4-18. **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.

5. Some Comments

We are still analyzing the test teaching of the course. However from the data already presented we may conclude:

- The course objectives have been met successfully. More specifically:
  - 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 appropriately such an 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)
- On the management and delivery of the course problems were located. Although most of the problems were expected due to the initially planned test teaching on a small scale, they are taken into account. The problem of the limited number of parts has been already solved with the purchase of more kits on a variety of component parts. This will also solve the problem of group size limiting it to two students per group (or three, in exceptional circumstances). However, this will mean an increased teachers' workload and more laboratory work space. The manuals in Greek is also taken into account although we do not think it as serious problem – our observations showed that, even when there was a Greek translation of the manuals, the students preferred a trial and error approach or the teachers' advice. The problem of time needs some more thought. It may mean that students workload for the course is high, as the students have already indicated. However, we did not notice any group working in the Laboratory for more than three hours in excess of the three teaching hours per week. On the assumption that a couple of hours of home study per actual teaching hour is a normal situation for a University course this comment of the students may simply mean that they can do the homework necessary for the course only in the Laboratory [4]. This aspect needs more study as the obvious solution to lend the whole kit to the group may pose administration and logistics problems as is evident from Figure 2. This point is still under study.
- Another point from the students' comments is to find the appropriate balance between the theoretical context and the possible use of educational robotics within the school curricula and the level of detail for the guidance on the actual practice work. Our observations indicate also that a closer connection between the techniques used to assemble the robot they plan and the underlying Science concepts would also help. The demands on the students' artefacts should also be considered to be appropriate to the time available.
- Students liked the course. They judged it as interesting, creative, different (with a positive meaning) from other courses and as one student explicitly wrote 'it took us a lot of time but it was worthy'. Even some of the negative aspects they were provoked by the questionnaire's structure to write may be considered as positive remarks, for example the comments in 4-7 above
- From the data we have so far there is no indication of any differentiation between girls

and boys, neither to their achievements or the marks obtained nor to their involvement as 'programmers' or constructors' or otherwise. The groups the students themselves had formed were included all girls or all boys as well as mixed groups with no apparent evidence of sex differentiation.

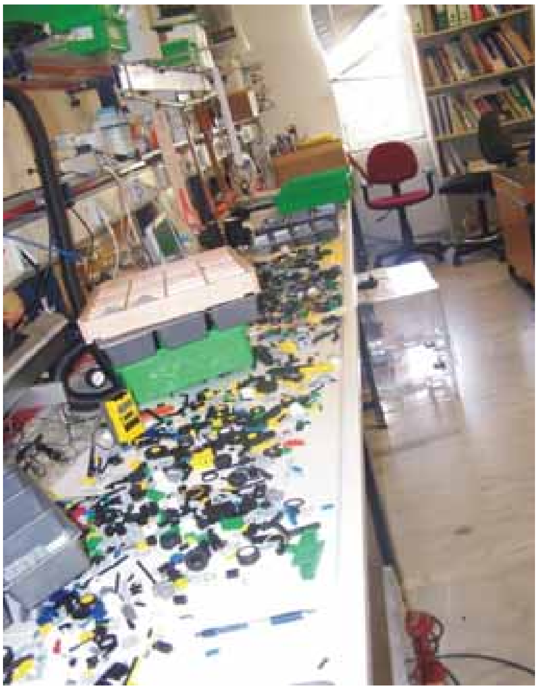

Figure 2. Overview of the workbench during a break of students' study

- The self-esteem of the students towards Science and Technology has increased, for example they feel confident that they could manage a similar teaching in school with themselves as teachers. This was also an explicit objective of the course and may explain, to some extent, the origin of the (negatively perceived) comment 'no praise on our efforts'.
- Another significant outcome is the students' comments that this course could be incorporated within the school activities. Even the negative answers (with three exceptions) 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.

In conclusion, we think that the test teaching was successful and we plan to include this course into the undergraduate curriculum on a regular basis.

6. Acknowledgements

We would like to thank our students Litsa, Athina, Amalia, Maria, Apostolis, Giorgos, Eleni, Marina, Spiros, Aristotelis, Giorgos, Dimitris, Katerina, Antelina, Dimitris, Stelios, Eugenia, Evi, Dionisia, Chrysanthi, Aggeliki, Kalliopi, Maria and Kalliopi. Their cooperation and the enthusiasm they showed during the whole course made our teaching a pleasant experience.

This work has been supported by the European Commission (project AESTIT - Contract 226381-CP-1-2005-1-GR-COMENIUS-C21). The views expressed here represent only the author of this work. Neither the Commission nor the author may be considered responsible for any use of the information contained here in.

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[2] The questionnaire was formally anonymous but due to the small number of students, an analysis of their answers could reveal the student (naturally, it was not made). However we believe that the students have responded sincerely. This is based to the good teachers - students relations and mutual confidence developed and the continuous encouragement of the students during the course to express their opinion, which they did, sometimes criticizing openly aspects of the course they considered as negative. Indirect similar evidence is from the fact that on similar other test teaching courses where a more thorough study was made there no indication of any bias was found.

[3] The constructed implementations included: 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.

[4] Another possible explanation is that because of the course structure and the active students' involvement, necessary for a course aiming at the development of problem solving skills, the homework has actually to be done in time for the next teaching session, while in other courses this may be left at the end of the semester.

Electric Art

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Abstract. Electric Art is a challenging and practical application of electricity and creativity. Participants will be presented with a cross-curricular application of Physics and Art that uses recycled materials. Art from the global scrap heap is the focus of this endeavor. Workshop includes goals, lesson plans and grading rubrics. Participants will receive a packet containing necessary materials for implementation. Project uses readily available materials.

The primary goal of the science component is to allow students to apply what they have learned about electricity and wiring to a hands-on project. After learning lab safety, how to wire a circuit and make a switch, they get to create an art piece that lights up, has an object that spins, or makes noises. The students will draw an accurate schematic diagram and be able to follow it to wire their art piece. They will apply their knowledge of how to strip wire, attach switches, motors, buzzers, and lights in parallel and series. Additionally, they will learn simple structural engineering techniques in order to create a sturdy and reliable final product.

The primary goal of the art component of this project is to encourage creativity by using only "found" objects to create esthetic and interesting art objects. The artworks must contain the required electrical circuitry. The students are introduced to "found art" through a series of prints of both global found art and contemporary artists who work with found objects. Through directed discussions, they learn about the process of seeing and transforming ordinary objects and trash, into meaningful and esthetic works of art. The second art component is the practice of using sketching to plan their artwork. They need to understand simple schematic drawing, i.e. aerial view, side view, details, etc., to do their planning.

Keywords. Electricity, Physics, Found Art.

From Electromagnetism to Electrodynamics: Ampère's Demonstration of the Interaction between Current Carrying Wires

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Abstract. We present Oersted's discovery of the torque exerted by a current carrying wire upon a nearby magnet and his interpretation of this experiment. This opened the field of electromagnetism, describing the interaction between current carrying wires and magnets. We discuss Ampère's alternative interpretation and his experiment showing a force between a magnet and a current carrying spiral. This led him to try an interaction between two current carrying spirals, without any magnet. He was successful with this trial and this is one of the most important experiments in the history of electricity. This led him to the result that current carrying parallel wires attract (repel) one another when the currents flow along the same direction (in opposite directions). This new field of research describing the interaction between current carrying wires was called electrodynamics by Ampère. We show how to perform Ampère's crucial experiment with simple and cheap materials.

Keywords. Ampère, Electro-dynamics, History of Physics, Low Cost Materials.

1. Introduction

Until the beginning of the nineteenth century there were some separate branches of physics including gravitation, electricity and magnetism. They were represented by inverse square central forces. The force of gravitation, F_g, was proportional to the product of the two masses, m_1 and m_2, and inversely proportional to the square