

Promoting engineering studies through summer camps of electronics and robotics

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ABSTRACT: Technology and engineering topics are inadequately represented in the national curriculum of general secondary education in Slovenia. Compulsory themes that are supposed to contribute to technology literacy have actually decreased over the past decade. The consequence of such an educational policy is low quantity and weak quality of students in higher education engineering studies. In order to popularise engineering subjects to youngsters aged 12 to 18 years, summer camps were carried out for three consecutive years integrating topics related to electronics, informatics, mechanical engineering, etc. For active engagement of the participants, the summer camp programme emphasised learning by *hands-on* exploration, whereas the final task was to develop projects according to their own ideas. The paper outlines the characteristics of equipment and software used in the programme, as well as reports on the participants' projects. Results of a questionnaire delivered to the participants at the end of the camp were analysed and the outcomes were encouraging, inspiring researchers to make expanding plans for the forthcoming years.

INTRODUCTION

Technical products that are used in everyday and in professional life are becoming more and more advanced and sophisticated. At first, they may be handled almost intuitively while efficient use is becoming increasingly complex. Even buying a new digital camera or television is now a demanding project, especially when trying to optimise price, performance and our real needs. Most of the technical devices have screens and buttons that allow to navigate through menus. Furthermore, optimal functionality of many advanced devices is supported by sensors and precise mechanisms, and they operate as a kind of *specialised computers*. The consequence of such trends is that the terms such as *digital competence* and *ICT literacy* have an important role to play in educational strategies and practices worldwide [1][2]. According to some institutions and authors, a term *technological literacy* has a more universal range [3][4]. Conversely, a highly developed society cannot be based only on well skilled users of technical devices, and the advanced economy should be involved in the planning, development, manufacturing and marketing of high technology products [5]. The founding for such an advanced economy should be the national educative system. To keep pace with technological developments, advanced themes should be introduced to curriculum in the earliest periods of education, as well as into colleges and higher schools. That is why technology education is seeking renewal [6- 8].

The situation regarding technology and engineering subjects has unfortunately become worse in Slovenia over the past decade. Representation of advanced engineering technologies in the curriculum of general secondary education in Slovenia (students aged 12 to 18) is poor. At the low-secondary level, the compulsory contents that may contribute to technology literacy even decreased. In addition, at upper-secondary schools (called grammar schools), technology themes are weakly integrated within science subjects (physics, chemistry, biology), whilst proper engineering topics are not even presented optionally. Despite the declaration that confirmed the importance of technical education by the Ministry of Education and Sport of Slovenia, the situation did not improve at all. Most of the over-average low-secondary students opt to go to general grammar schools (called gymnasium), while technical vocational high-schools seem to be a kind of *escape choice*. The number of students enrolled in the higher engineering schools is improving slightly in recent years, but the background knowledge of freshmen students regarding engineering, mathematics and science is decreasing.

CONCEPTS AND AIMS OF THE SUMMER CAMPS

Since the situation within formal education in Slovenia is not promising, and the influence of engineering educators to education policy of the country is negligible, some attempts to improve the situation have been targeted to non-formal education. Establishing summer camps that focus on robotics and electronics is one of them.

In order to introduce integrated engineering content to youngsters aged 12 to 18 years, summer camps were held by the Slovenian Association for Technical Culture and the Association for the Development of Technical Education for three consecutive years. This summer, 30 participants were divided into two groups, one with 17 youngsters focused on electronics and the rest of them focused on robotics. The didactic concept of a one-week summer camp programme was based on hands-on exploration emphasising empirical and problem-based didactic approach. The aim of the programme was to develop advanced cognitive levels of knowledge, especially analysis and synthesis according to Bloom's taxonomy, which is particularly important for engineering disciplines [9]. For that reason, participants explored properties and usage of electronics components, motors, sensors, mechanisms, programming environment, simulation software, etc; the first three days, following the learning by doing approach. Participants were coached by mentors in order for participants to develop autonomous projects according to their own ideas. Participants also prepared short written reports about their projects, which were collected and formatted on a DVD. On the last day, they also presented the projects to each other and to parents.

PROGRAMME OF THE ELECTRONICS SUMMER CAMP

The summer camp programme was developed on the basis of experience in conducting lectures and laboratory work in electronics courses at the Faculty of Education, University of Ljubljana, Slovenia [10]. In particular, it was considered that introductory learning of electronics should be based on practical laboratory work with real circuits [11]. The basis was practical assembly and testing of circuits on prototyping solderless breadboards, a universal measuring instrument and a collection of electronic components such as resistors, resistance sensors, capacitors, diodes, transistors, operational amplifiers, logic gates, RS flip-flops, DC motors, etc (Figure 1). Participants also soldered a stable multi-vibrator on the perforated plate. Participants were especially amazed while applying microcontroller based module named eProDas-Rob1 [12], which they programmed in the programming environment Bascom for AVR microcontrollers. The module connected to a PC was implemented as a digital signal generator, analyser of digital and analogue signals (Figure 2) or as an oscilloscope; each station was, therefore, equipped with a laptop. The eProDas-Rob1 and supporting software have been developed at the Faculty of Education within the EU Leonardo da Vinci programme (project ComLab, www.e-prolab.com).

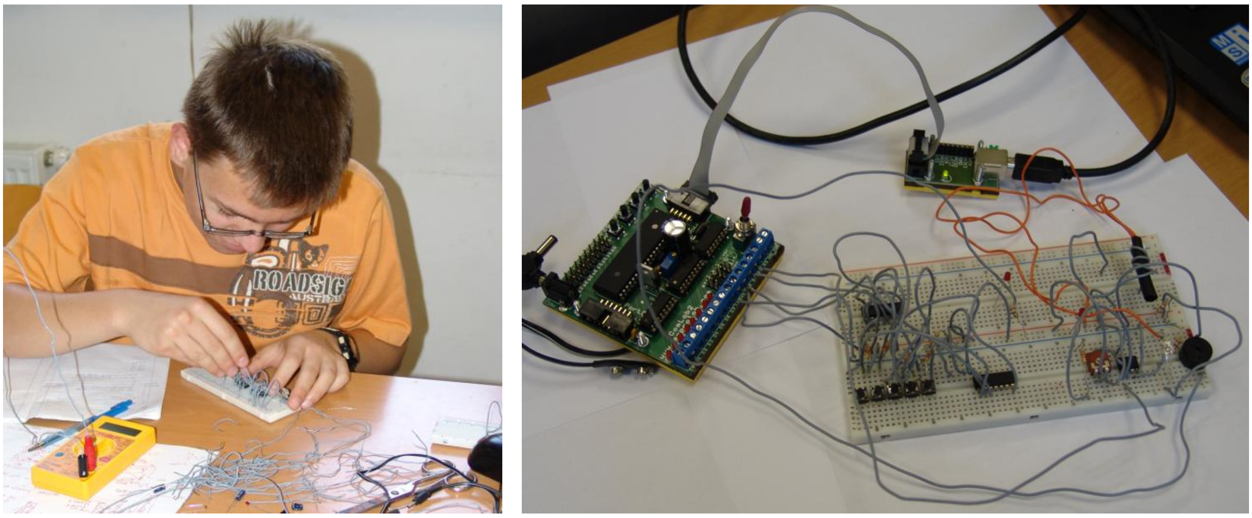

Figure 1: Assembling a circuit at the protoboard combined also with the microcontroller unit.

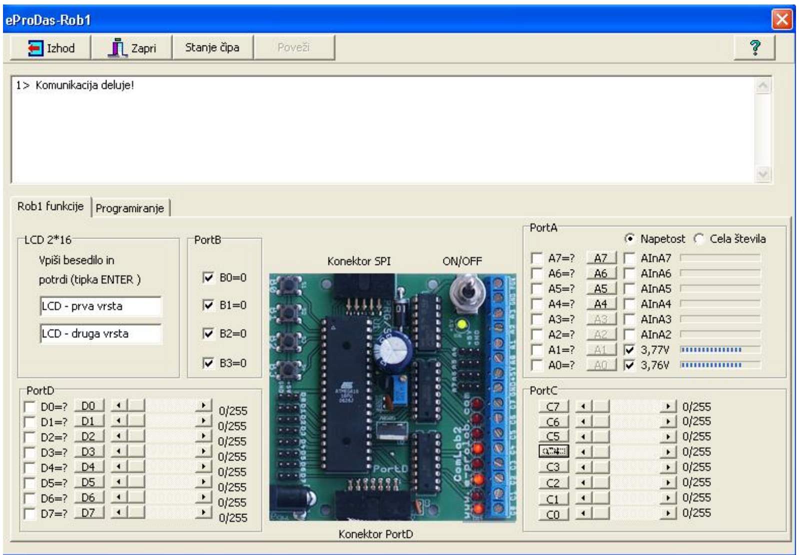

Figure 2: PC screen during test of the microcontroller unit eProDas-Rob1.

Simulations of circuits are an integral part of the teaching of electronics. Dilemmas about the so-called *virtual* in relation to real laboratory practice are well known in science education [13][14]. Although the programme of the camp stressed practical experience, the real lab was still combined with the Yenka Technology software (http://www.yenka.com), formerly known as Crocodile clips [15]. An example simulation circuit as displayed on a PC screen is shown in Figure 3.

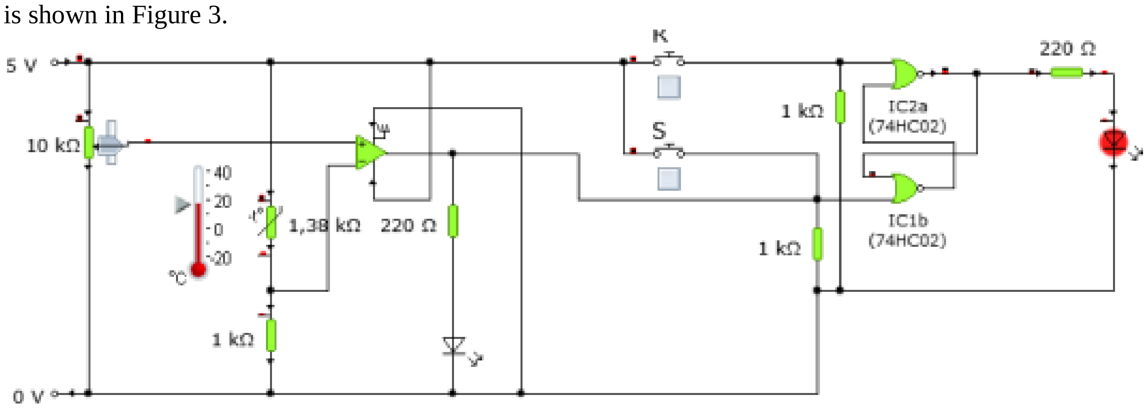

Figure 3: PC screen capture with simulated circuit.

PROGRAMME OF THE ROBOTICS SUMMER CAMP

Participants learnt the first steps in computer programming of models of robots and other programmable devices. A free version of Microsoft Visual Basic (Express Edition) was implemented for so-called on-line programming. During initialisation, a firmware is uploaded from a PC to the eProDas-Rob1 microcontroller module (the same as shown in Figure 1) to support continuous (or on-line) communication via USB. Core dynamic link library (dll) and programming libraries have been developed to support not only programming in Visual Basic, but also in Turbo Delphi, LabView, Visual C++, etc. For autonomous operation of the microcontroller module, shareware version of AVR Bascom compiler was implemented since it is founded on Basic programming language too. Any other compiler for Atmel microcontroller could also be used, including AVR Pascal, AVR Studio, etc.

In parallel to programming of the module, participants get acquainted with the basic principles of the operation of machines and mechanisms. They implemented sensors, actuators, gears, construction kits, etc. Unlike the approach of commercial producers such as Lego, the participants can easily design their own sensors, constructions, mechanisms and implement different freely available programming environments. Projects they develop are not just models of robots; they also develop models of other digitally controlled systems according to their own ideas.

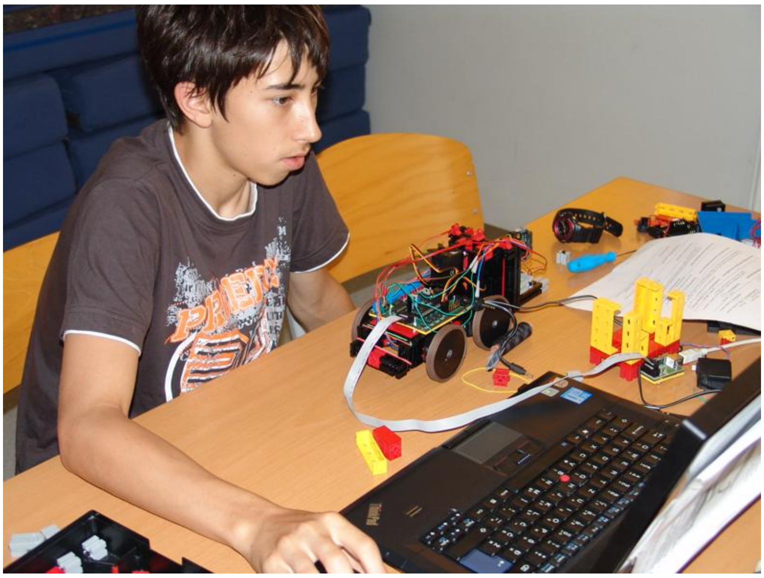

Figure 4: Combining different kits.

EXAMPLE PROJECTS

In order to provide an insight into the final projects performed by participants, a couple of reports were outlined.

Automatic transmission gears, Luka Rudman and Jaka Zupan.
Aim: We got our inspiration from the BMW 320D, which has automatic transmission gears. We first planned to have five steps, but it was not feasible, therefore, ours has only three.

Design: We installed the panel stand to which we mounted gears of different sizes. The gearbox includes three switches, a propeller, two motors and seven gears (Figure 5).

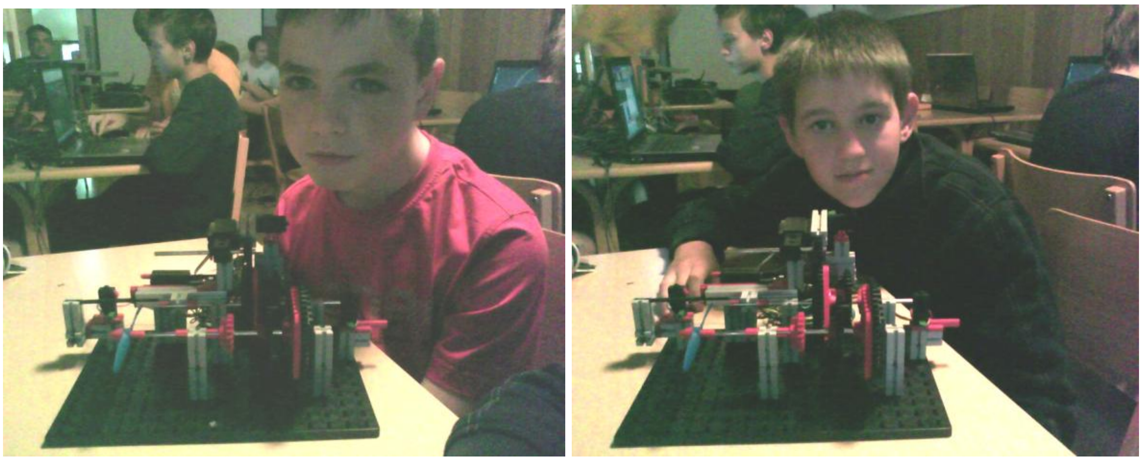

Figure 5: Model of automatic transmission gears.

Conclusion: At the end, it appeared that the whole thing almost did not differ from our expectations. Still, we would like to implement at least a fourth gear.
Suggestions: It was good that we could work with our own projects. Next year the project work should last for three days, not just two.

Autonomous forklift, Bor Klančar and Aleksander Rajhard.
Aim: a) forklift moving forward, backward and turning; b) forks to move up and down; c) forklift to shift objects from one location to other.
Design: The forklift was assembled from four DC motors, two servo motors, an infrared distance sensor, two touch sensors, an LCD screen and a whole bunch of Fischer Technik elements. We programmed in Bascom. The robot looks like a car with a moving forks (Figure 6).
Conclusion: Our forklift can move autonomously according to signals from the distance sensor. We are proud that we solved the problems with the implementation of the distance sensor. If we had more time, we would have liked to be able to look for objects more than 40 cm from the forklift.
Suggestions: we enjoyed working with robots. During the free time we would like to do whatever we want.

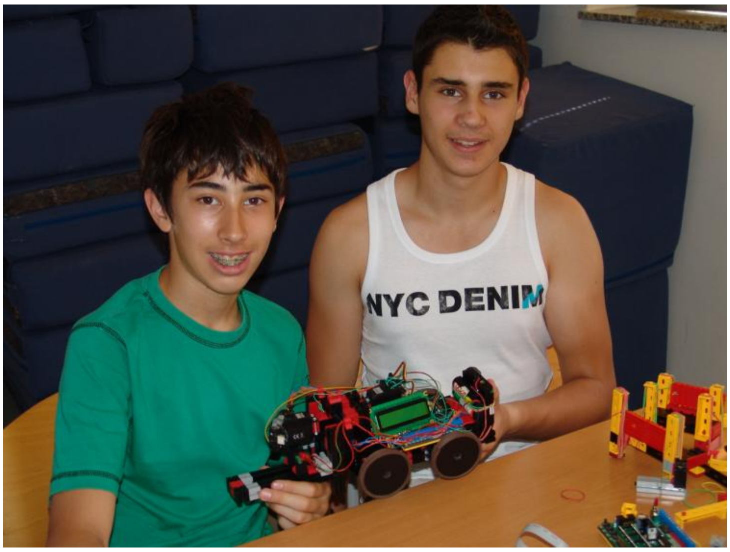

Figure 6: Model of an autonomous forklift.

Temperature control, Martin Urigelj and Tomaž Kernc.
Aim: Automatic activation of a fan in case the temperature of an object increases.
Design: For the project we used NTC thermistors, potentiometers to set the required temperature, a transistor as a switch, two resistors, LEDs and an operational amplifier as comparator. All the components were wired on the protoboard. When the temperature exceeds an adjustable limit, the red LED is switched on and the fan runs.
Conclusion: We managed to do as we planned. We also wanted to install a moisture regulator in the room, but we did not have a moisture sensor.

Suggestions: We liked the food, basketball, rafting on the Kolpa River and swimming. For the next year, we would propose to have a more complex workshop in the field of electronics.

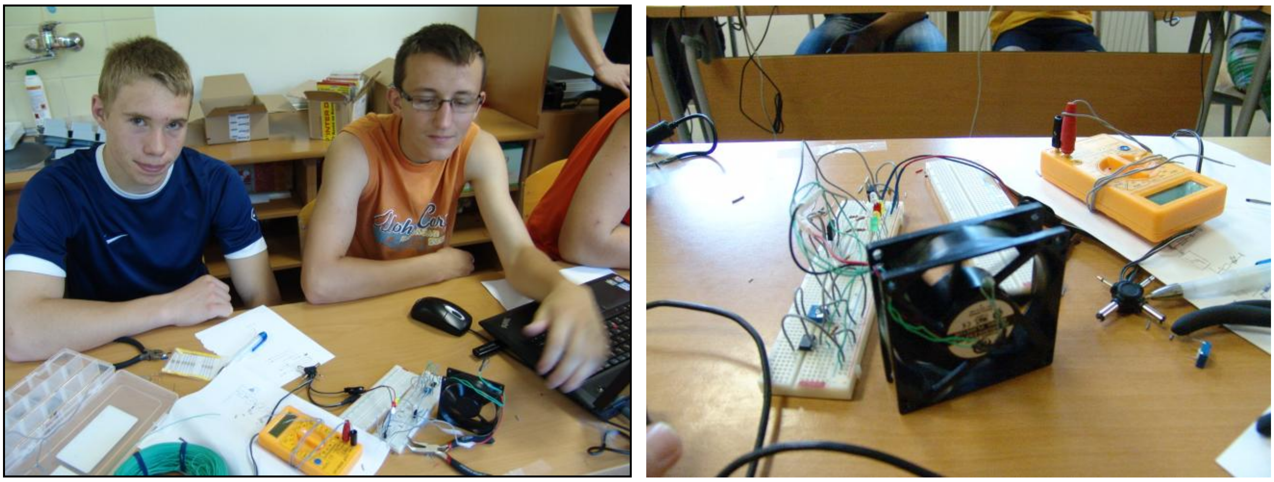

Figure 7: Temperature control using a fan.

EVALUATION

At the end of the camp, a short questionnaire was delivered to the participants. Figure 8 represents the appreciation of the group working on electronics. The response of the robotics group was similar.

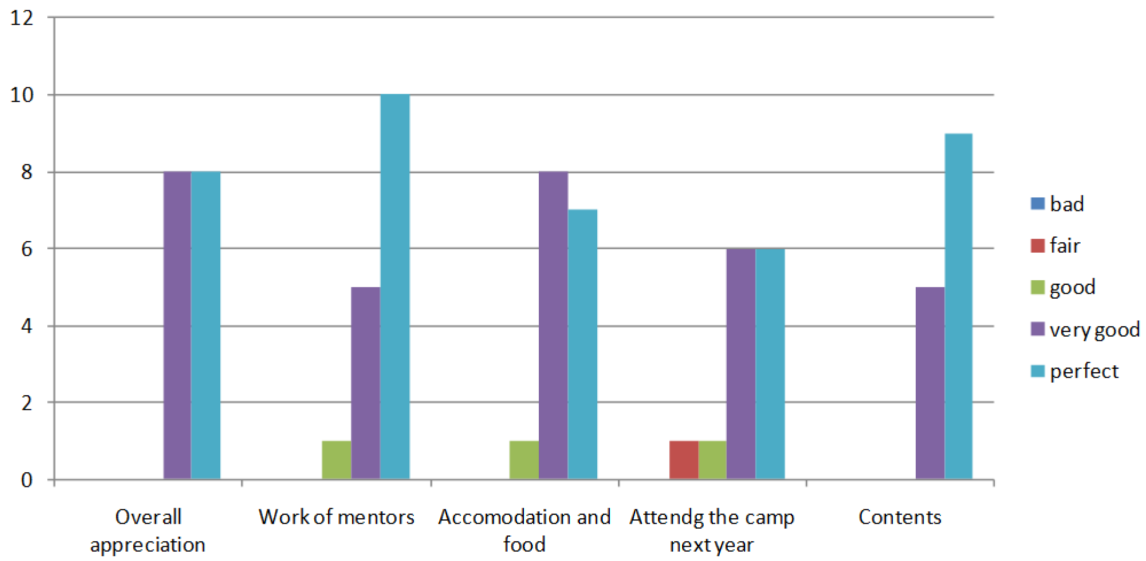

Figure 8: Responses of participants to the questionnaire.

To the question on why they attended the electronics camp, the answer of 14 out of 17 was that they were interested in electronics, one because of the nice location, and two because of a suggestion from a friend (attending the camp earlier).

CONCLUSIONS

The authors of this paper, as well as other mentors, believe that even the small steps that were taken through the preparation and implementation of robotics and electronics summer camps may lead to the enhancement of the status, role and quality of engineering and technology education. The bases for this claim are the following:

- Increasing numbers of participants from year to year.
- Positive response of participants, their enthusiasm and good responses to the questionnaire.
- High-quality and innovative projects performed by the participants, which are comparable with the projects of in-service and pre-service teachers at the end of similar courses.
- Encouragement to the organisers expressed by some parents, especially those from the engineering profession.

Future plans are to continue the summer camps, perhaps on a wider scale, to implement experiences and didactic methods to offer optional subjects to the middle-school level and to organise in-service training of teachers.

Nevertheless, the authors would like to influence those who make decisions on educational short-term and long-term strategies.

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