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# Electronics course for in-service teachers of engineering and technology

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ABSTRACT: Initial teaching of electronics is important as a way to motivate school students in continuing education in this field, which is especially significant at the end of middle school, when school students decide on their choice of profession. But because teachers are not as familiar with electronics as it would be desired, the authors have developed in-service training for teachers of elective Electronics. It uses problem-based tasks, in which teachers empirically get to know electronic circuits and components. The authors worked with the electronic kit eProKit-El1, power supply eProKit-PS1 and working papers, developed for this purpose at the Faculty of Education of the University of Ljubljana in Slovenia. Teacher responses generally were highly positive. Furthermore, they were satisfied with the implementation and working material for the in-service training. They have expressed a desire for in-depth in-service training, to expand the knowledge they have acquired. Summarised in this article is the progress and analysis of the in-service training.

## INTRODUCTION

Devices with sophisticated electronics are a part of our everyday lives. They have become increasingly complex, with touch screens and keyboards that allow choice of menu and through them the selection of programmes. Many such devices include sensors and gadgets which youngsters especially like to use and, in most cases, to play with. It seems the development of contemporary electronics is not adequately represented in pre-higher education, where the students decide their lifelong profession. However, electronics devices are not just a tool to be used; their effective usage is a part of *technological literacy*.

Technological literacy is an important factor in assessing the level of development of a society. It has a significant role in several areas and, it can be said, is becoming universal [1][2]. Although many countries recognise the importance of technology, analyses of technology education curricula in six countries have shown that topics concerning technology are not tested at the national level [3]. Therefore, in the US, plans are under way for the initial assessment of technological literacy, which should be carried out in 2014 [4][5].

In Slovenia, the first national assessment of engineering and technology was conducted in 2008 and the latest in 2010. The 2010 results have shown a significant difference between basic and higher level taxonomic tasks, the latter of which were very poorly solved [6]. Therefore, there is a lot of opportunity to introduce electronics into Slovenia's middle schools [7].

This is, obviously, the case in the Slovenian educational system. In the middle school (students aged 12 to 15 years), the compulsory technology topics that could contribute to sustaining technological literacy of youngsters has decreased in the past decade. Fortunately, teachers have the opportunity to teach some elective courses in engineering topics, such as robotics, electronics, electrical engineering, technology design. Because of insufficient knowledge, skills and experiences, and the fact that schools are not adequately equipped to carry out these electives subjects, teachers have many problems. The curricula cannot precisely specify the teaching equipment, accessories, tools and software, etc. In addition, there are no textbooks, workbooks or other teaching materials for most of the elective subjects, such as Electronics.

Since there is no control over how and what teachers teach in electives, the decision to develop integrated teaching materials is very important. For that purpose, the authors developed a laboratory hands-on kit and working papers that were initially applied to a summer school on electronics in 2010 [8][9] and 2011 [10]. Because of the positive feedback encountered from more than 30 students aged 12 to 16 years, the authors decided to develop and conduct in-service training for teachers to implement developed working material and a didactic approach to its use.

CONCEPTS AND AIMS OF THE IN-SERVICE TRAINING FOR TEACHERS OF ELECTIVE ELECTRONICS

To increase the level of knowledge and skills of teachers for the elective electronics course and to introduce these topics to students in the middle school, the authors carried out in-service teacher training (Figure 1) in the Department of Physics and Technology at the Faculty of Education in November and December 2011.

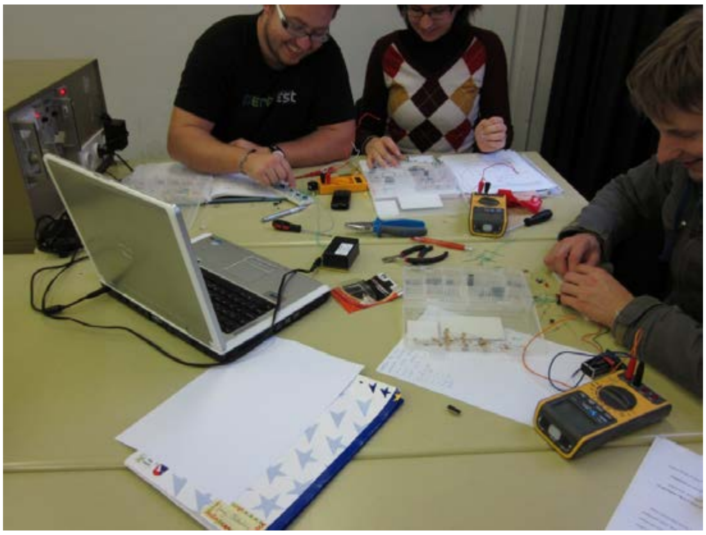

Figure 1: Teachers experiment with electronic circuits.

All electives in the middle school have a prescribed curriculum, and elective Electronics is no exception. Because of the experiences gained during summer schools for students, a didactic approach to teaching was decided upon. The fact that no appropriate kit or collection of teaching material could be found on the market has led to the development of basic kit eProKit-El1 (Figure 2), power supply eProKit-PS1 (Figure 2) and working papers. EProKit-El1 includes the basic electronics components, such as resistors, sensors, capacitors, diodes, transistors, bulbs, operational amplifiers, logic gates, flip flops, voltage regulator 7805 and a prototyping board. The kit was designed to enable straightforward assembly with additional components, if required, such as a microcontroller unit based on the Atmel AVR ATMega16 unit, and programming simulations, such as Yenka design and technology [11][12]. Since not all the schools have the needed equipment or instruments, the authors provided additional accessories, such as power supply eProKit-PS1, multimeter, DC motor and servo motor.

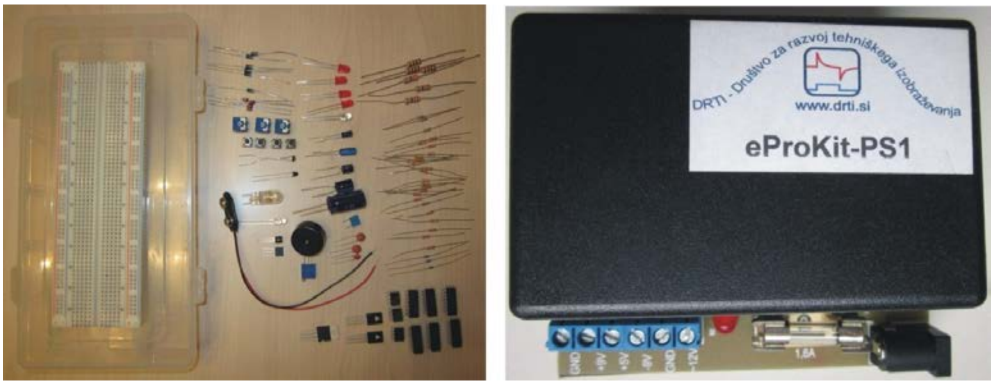


Figure 2: Basic electronics kit eProKit-El1 (l); and Power supply eProKit-PS1 (r).

The didactic concept of 24-hour in-service teacher training was implemented using problem-based tasks. There were many hands-on explorations of electronic circuits and almost no upfront theoretical explanations, since teachers empirically arrived at the correct answers. By doing so, there was a tendency to develop higher taxonomic levels of knowledge, particularly analysis and synthesis according to Bloom's taxonomy [13]. These are both very important in the engineering professions. Although it is believed that classroom problems are substantively different from the kinds of problems met in the workplace [14], it is important to implement such problem-based tasks in teaching practice [15].

IN-SERVICE TRAINING PROGRAMME FOR TEACHERS OF ELECTIVE ELECTRONICS

The in-service teacher training programme was divided into three parts. The first part included a short introduction and explanation of the purpose of in-service training. Afterwards, the programme participants (teachers) were introduced to the basic electronics kit, eProKit-El1, which includes electronic components. All of the components were presented briefly. This was followed by an explanation of the didactic approach and the hands-on experiments with electronic circuits. The participants received sample working papers developed for students of the elective Electronics course. Initially, they were introduced to prototyping boards and a voltage regulator. Afterwards, the participants measured a current and voltage in simple circuits with one or two resistors, one of them a light dependent resistor. Later, they wired a voltage comparator based on an operational amplifier, R-S flipflop and an astable multivibrator. At the output, they used a light emitting diode to check the operation of the circuit. A sample problem-based task was to make a circuit that would function similarly to automatic street lighting: as the sky darkens, street lights are turned on, and in the morning, they are turned off. Since the course participants already had used the light dependent resistor and voltage comparator, they wired them and the light emitting diode (LED) indicated, if it was dark or bright. However, if they connected a bulb to provide additional illumination directly between the comparator output and ground (in parallel to R2 and D1 on Figure 3), the bulb was not turned on. However, the circuit with only the LED (D1) still worked and this meant there was something else wrong. Thereafter, the participants used the transistor and working circuit shown in Figure 3 to provide the working solution.

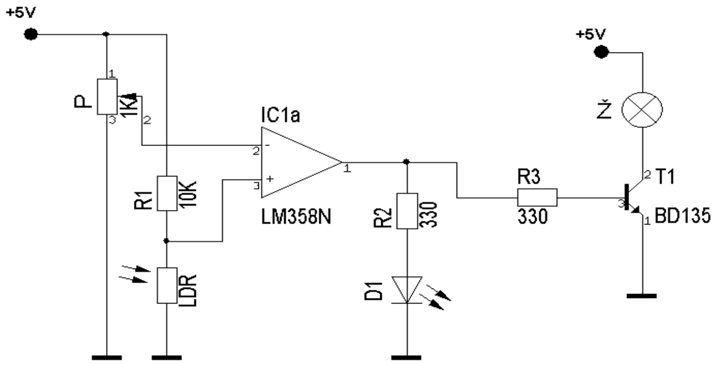


Figure 3: Voltage regulator with transistor and bulb.

In the second part of the in-service training, teachers are motivated to plan, design and develop their own projects. Throughout, assistance was given to them via e-mail and/or Skype. Many teachers sought help and with some additional information, they solved problems and completed the tasks. The third part of the in-service teacher programme covered the presentation of all projects followed up by a debate, where teachers and lecturers delivered their reflections on projects and proposed improvements. Teachers considered these proposals and after improving the projects, sent reports by e-mail.

IN-SERVICE TEACHER PROJECTS

In-service training was attended by 14 teachers. All were required to prepare a project that could be made with electronics kit eProKit-El1, in class and by students. Unfortunately, just six teachers submitted their project. Furthermore, the projects tended to be straightforward, although more challenging projects were encouraged. They also had to make up questions regarding their electronic circuit. All of this, with photographs and electronic schemes, had to be written down and submitted for review. One such example of a project carried out by teachers during training is shown below.

Lamp Activation with Infrared (IR) Remote Control

Aim: To assemble an electronic circuit on a proto(type) board, which will allow activation of the lamp with any IR remote control, such as a TV remote control.

Design: As an example, here is an assembled circuit on a proto board (Figure 4) and a circuit scheme (Figure 5). For power supply, eProKit-PS1 was used.

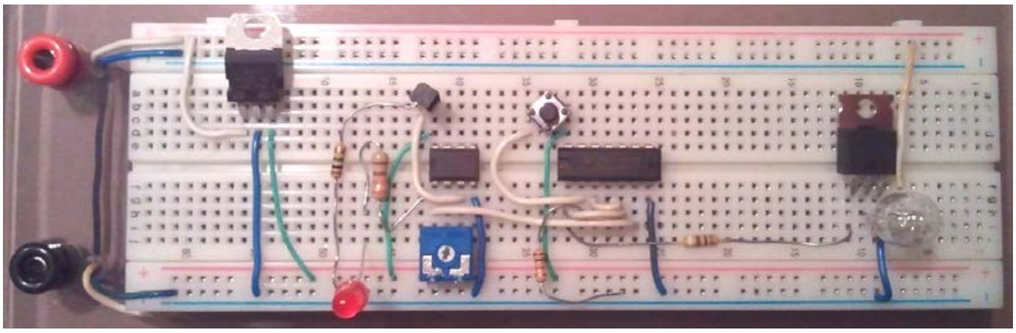

Figure 4: Electronic circuit on proto board.

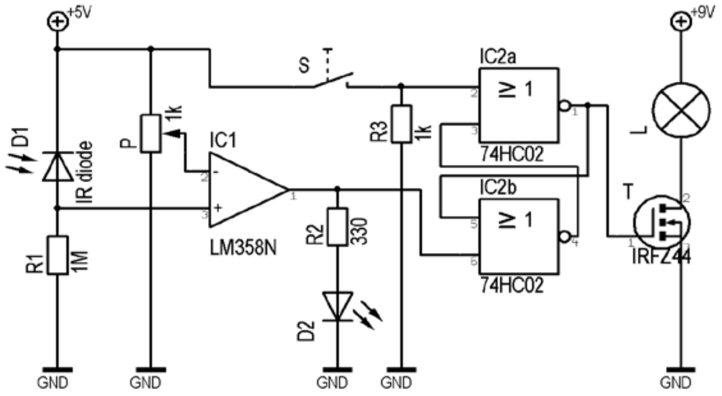


Figure 5: Scheme of lamp remote activation.

Analysis of electronic circuit: After wiring a circuit board, students should measure the voltage at the two inputs and the output of the voltage comparator, on the output of the RS flip flop and on the lamp. Measurements are made when there is no IR signal and when the IR signal is present. The IR signal is emitted to an IR diode in any remote control (say, from a TV set). The findings of the students are recorded in a table. Afterwards, students must solve written tasks, in most cases closed-type tasks with three or more choices. Example question: *Give an example where the correct choice is underlined - the infrared controller emits: ultrasonic sound, visible light, invisible light, small quantum particles*. Additional tasks: For faster, more advanced students additional tasks were added. As an example, instead of switching off the RS flip flop, one must turn it off using a thermistor (NTC) that has to be sufficiently warmed up by the lamp. Furthermore, before wiring the circuit, the students needed to draw the circuit diagram.

EVALUATION

After the in-service training, the teachers filled out an on-line questionnaire. Analysis revealed some important answers about motivation, didactical approach, working materials and teaching practice of elective Electronics course. The in-service training of teachers of elective Electronics involved 14 teachers of Engineering and Technology from 14 middle schools. There were 11 male and three female participants aged between 26 and 54.

Analysis of Inquiry

Questionnaires were sent to 14 teachers. They all responded and filled out the questionnaire. The analysis of responses to a question on the reason for attending in-service training is shown in Figure 6.

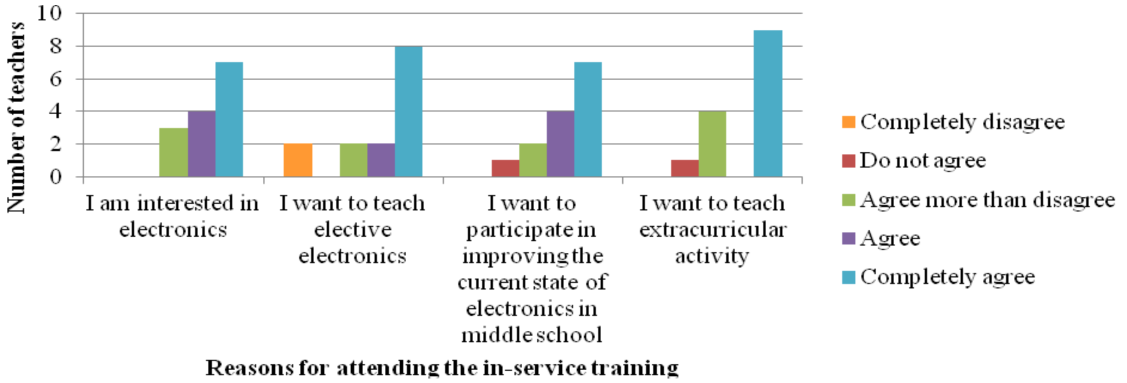


Figure 6: Histogram presenting reasons for attending the in-service training for elective Electronics.

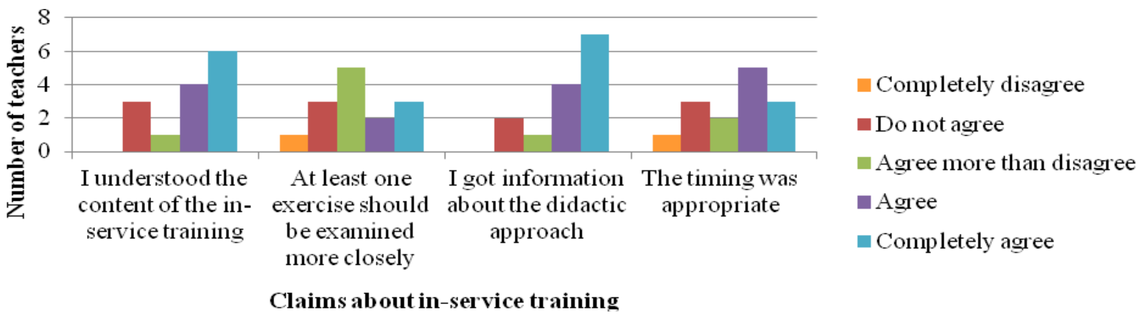


Figure 7: Histogram that shows how much teachers agree with claims about the in-service training.

Most teachers agreed that the programme of in-service training was well prepared and that they obtained information they needed (Figure 7). Working materials were considered useful and applicable, as shown in Figure 7.

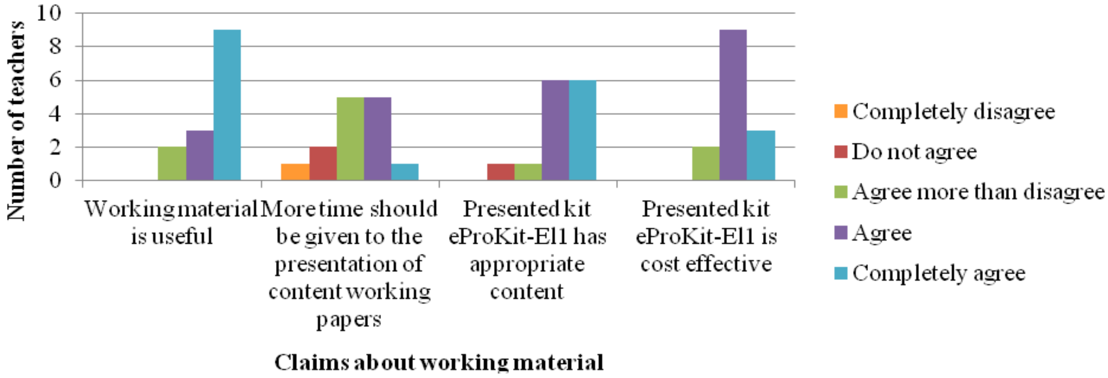


Figure 8: Histogram that shows how much teachers agree with claims about working material.

To show that the in-service training for elective Electronics is on the right track, the answer about teacher expectations is very important, because teachers are practitioners working with school students, who are the targeted population. It can be seen that the in-service training programme managed to satisfy more or less the needs of every teacher (Figure 9).

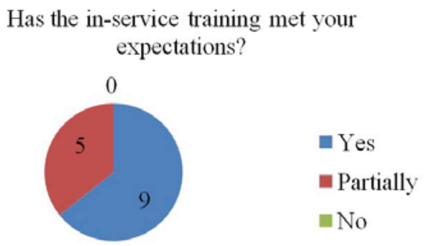


Figure 9: Pie chart on meeting the expectations set by the in-service training.

Teachers who are already teaching elective Electronics in this school year are planning to continue to do so next year; in addition, there are six other teachers who may offer this elective, and only two decided not to (Figure 10).

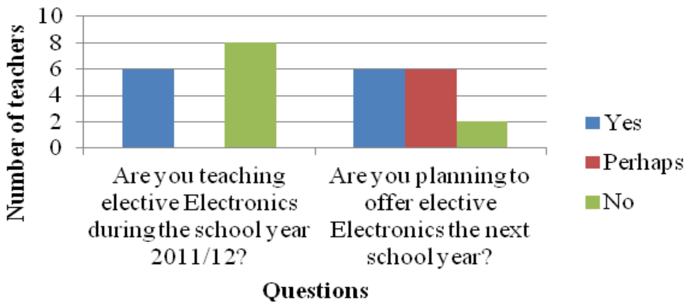


Figure 10: Histogram on teaching elective Electronics during the school year 2011/2012 and planning to offer elective Electronics in the next school year.

## CONCLUSIONS

According to the evaluation, it was estimated that in-service training successfully introduced both didactic approaches and the working materials for elective Electronics. Notwithstanding the positive results and experience in teaching electronics, it is necessary to upgrade materials and to follow-up new developments, as only in this way can motivation be maintained for school students who continue their education in this field.

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