ALTERNATIVE WAYS OF TEACHING PROGRAMMING OF LOWCOST CONTROL UNITS (ARDUINO)

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Abstract

The paper deals with the issue of technology education at secondary vocational schools. The aim of the authors is to design a teaching system which, through its content and way of subject matter presentation, will contribute to a better understanding of programming patterns by secondary vocational school students, especially in the area of logical systems. In particular, the authors deal with designing of a teaching system for programming of lowcost (Arduino) control units. They describe alternative ways of teaching lowcost control units based on different ways of knowledge and information presentation. These alternative ways use dominantly either text elements or image and text instructions or video instructions. A research question for the authors is which way in conjunction with what kind of information is more effective in terms of teaching efficiency and students´ learning achievements (from the programming point of view).

Keywords: Alternative teaching forms and methods, innovative didactic strategies, lowcost control units, Arduino, technology education, secondary vocational schools.

1 INTRODUCTION

Quality assurance of technology education is a frequently discussed topic not only among experts but also among teachers, which are involved in implementation of this kind of education at different levels of schools (from the lowest ISCED 0 level to the highest ISCED 6 level). At the same time quality assurance of this education is closely linked to the quality and preparedness of teaching staff, to the content of education and, last but not least, to the way in which the content of the curricula is presented to students. The latter aspect is particularly important in technical education of students of secondary vocational schools, at such subjects as programming, applied informatics or computing. It is the way in which the subject matter is presented what plays an important role in understanding of the lesson content by students and in acquiring and developing students´ knowledge and skills ([1], [2]). Especially when it comes to thematic units focusing on the areas of programming logic circuits or electronics.

In conjunction with technical education at secondary vocational schools, the acquired theoretical knowledge creates a platform for understanding the soundness and principles of technology. Therefore, the thematic units of theorectical teaching must be conceived as support for the practical preparation of students, which are usually taken by students in specialized laboratories or specialized classrooms. Last but not least, the training of students must also meet the needs of industrial practice. In connection with the teaching of programming patterns, logical systems and lowcost control units, the theoretical curriculum must also be focused on electronic components and their applications in electronic circuits, electronic devices and microprocessor technology. On the one hand, students should acquire theoretical knowledge of basic electronic components and their use in practice. On the other hand, however, they should also be able to work on basic electronic equipment, where the focus is mainly on the business side and the acquisition of the necessary practical skills.

In recent years, the lowcost Arduino platform has become a very helpful learning tool, thanks to which students show increased interest in programming and technically oriented subjects. As an Arduino teaching aid, it is primarily used to teach programming and electronics. It can be used to create separate interactive connections or can be used as part of other electronic connections. Its platform is based on the Wiring environment, specifically based on the ATMega328 microcontroller from Atmel and the IDE (Integrated Development Environment) graphical development environment.

In the secondary level, working with lowcost controllers provides students with the opportunity to acquire the knowledge and skills needed to work with JMP (single chip microcontrollers). Students also gain knowledge of code writing, specifically through the C programming language. They learn about the JMP programming principles and acquire the basics for solving more complex tasks that they usually solve in higher grades. At the same time they will gain the basis for programming in other programming languages (C #, C ++).
In the broadest sense, lowcost devices can be divided into two types. The first is the Arduino microcontroller and its modifications. The second is the Raspberry Pi minicomputer, which can fully represent the control member or even the computer. Both types of controllers (Arduino and Raspberry Pi) are cost-effective, relatively programmable and have strong third-party support. Since these platforms are open source, a large number of types and designs are created [3].

Increased interest in programming and technically oriented subjects is also aided by the modified content of practical exercises, which are focused on the design and verification of electronic circuits with a continuous and logical signal. Students are provided with various accessories and aids to help them implement these connections. The lessons thus have the character of laboratory exercises in which students are divided into groups of 8-10 students per group (legislative numbers of students for laboratory exercises). Students in each group perform the tasks assigned to them by the teacher during the first exercise, thus acquiring the necessary knowledge and skills they will need for further exercises. It is only later that the teaching strategy is applied, in which students can co-decide, cooperate and, in part, form their own involvement. At this stage, the teacher acts as a motivator who encourages and leads the students to the best of their performance. Individual themes are designed to develop students' logical thinking, expand their knowledge and improve their skills [4].

2 METHODOLOGY OF THE DESIGN OF THE INNOVATED WAY OF TEACHING LOWCOST CONTROL UNIT PROGRAMMING

As teachers of technically oriented subjects and trainers of these subject trainees, we are fully aware of the importance of the fact that the vocational training of secondary vocational schools has to meet current requirements of employers and labour market. That is why it is necessary to modify and innovate both content and forms of vocational training at secondary technical schools. Dealing with this issue we have started to design alternative ways of teaching programming of lowcost control units to find out the best way to teach the relevant topics.

There is an interesting paradox in teaching programming. It is proven that a person can learn new information faster if it is submitted via video than when s/he has information conveyed in the form of text and picture manuals [5]. But it is not quite so in technology and programming. Just text and picture instructions are at the forefront of video-mediated information. From this knowledge, we base our design on alternative ways of teaching lowcost controllers. That is why the alternative ways of teaching, we are dealing with, are based on different ways of knowledge and information presentation. These alternative ways use dominantly either text elements or image and text instructions or video instructions. As part of the modification of the curriculum and method of teaching programming, the interpretation of practical exercises has been fundamentally altered. A research question for us is which way in conjunction with what kind of information is more effective in terms of teaching efficiency and students` learning achievements (from the programming point of view).

Following the above-mentioned philosophy of the innovation of teaching the lowcost control unit programming and research of the designed innovative way of the teaching, there was created an educational website focused on the lowcost control units Arduino programming.

In addition to the educational purposes, the created website also serves as a tool for collecting information (research data) needed to compile an output optimum model (in terms of content and form of the innovated model) of education in microcontroller programming. We collect the relevant data both by monitoring and evaluating the application of alternative ways of communicating information (new subject matter) to teaching students and by semi-structured interviews ([6], [7]).

On the basis of the analysis of the State Education Program, students of the second and third year of secondary vocational schools were identified as respondents of the research. The experiment is carried out as part of the course Computer Science and Programming, specifically the thematic units of the Arduino project and single-chip microcontrollers, the extent of teaching is 33 lessons (1 lesson per week). Students also have theoretical teaching that is designed as a support, but we focus mainly on practical exercises.

We set the number of topics to sixteen, with each theme being scheduled for a two-hour exercise. Since laboratory exercises are always two-hour long, the number of topics suited us (16 themes x 2). They include thematic units as the basics of programming lowcost units as well as more advanced tasks in which students engage and program more demanding active and passive electronic components or sensors. Gradually, students come into contact with various types of motors (direct current motors (DC
motors), stepper motors, servo-motors) and finally work on more demanding practical tasks. Later in the exercise, they themselves come up with given assignments.

Three groups of respondents are created in the experiment. The control group is not used, as it is a qualitative research.

In the first group, practical instructions are implemented through textbooks created for individual exercises that are located on the created website (Figure 1).

Figure 1. List of the assignments for programming.

The second group of students has access to the same exercise content. The difference is in submitting the information on the basis of which this group solves individual tasks. This group is provided with information solely through pictorial and textual instructions (Figure 2).

Figure 2. Example of the assignments for the second group of students.

The third group of students carries out the same assignments but based on the information provided through the video tutorials (Figure 3).

Figure 3. Example of the assignments for the third group of students.
List of the topics to the particular assignments

1 Technical means of Arduino

In this theme, students are dedicated to describing the Arduino microcontroller. They get information on how to connect the microcontroller to the source and to the PC. The teacher describes the inputs and outputs of the microcontroller, presents the application programming model, its block diagram and development environment. It emphasizes the importance of the development environment, its features and usage. It teaches students to work in the development environment and finally demonstrates programming a simple application Basic program - LED blinking. Consequently, students have the task to try this program themselves.

2 Programming simple applications

In this topic, students begin to devote themselves to simple programming work. They are explained with the connection and work with LED program, a program for controlling the traffic light with timing. As the students only go through the introduction of programming, it is important to emphasize that they understand the subject matter and then write it themselves.

3 Programming simple applications

The given assignment adds to the basic programs and next item - Button. A student is presented with information and instructions for controlling the LED through the button. The teacher points to the basic IF and switch commands. At the same exercises, students learn to solve tasks through serial communication. As a practical example, they have the task of resolving work with the LED group as well as programs using iterative commands as a supporting element for these exercises.

4 Programming of analog inputs

Within this theme, students learn about working with analog inputs, connecting a potentiometer, measuring voltage and solving tasks such as output control using PWM (pulse width modulation).

5 Programming more complex applications

Under this theme, students are familiar with connecting and managing LCD (liquid crystal display), LCD display and task solving with LCD. We are also adding a speaker connection and working with a speaker to learn how to control it. As this topic is not time-consuming and technically demanding, it can be combined.

6 Programming more complex applications: connecting DC (direct current) motor and DC motor control

Students are guided through the exercises to learn the correct principles of DC motor programming. They learn to work with the control electronics that are essential to the proper operation of the motor.

7 Stepper motor control

In this topic, students learn the right steps for stepper motor, stepper motor control and programming. They also learn to work with additional control electronics that are essential to the proper operation of the stepper motor.

8 Servomotor control

Students learn to connect a servo motor (servo motor) and learn the basic principles of programming. Since this type of motor is highly represented in practice, it is important to know the patterns and possible problems associated with programming.

9 Arduino, relay and transistor switching elements

In this exercise, students use the knowledge of electronics to learn how to properly engage and program Arduino that is used as a control element. The transistor and relay play the role of a switch in this exercise, through which students switch more power-intensive devices.

10 Connecting the electronic components to the Arduino

In this exercise, students use the knowledge of electronics as well as the knowledge of previous exercises. They add knowledge from the theoretical lessons of computer science. As an auxiliary integrated circuit, the students engage a timer (NE555 timer). It is the most versatile and very popular circuit through which many schemes can be plugged in.
11 Connecting electronic components to Arduino
In this exercise, students add a shift register to the Arduino and Timer. This involvement is one of the most challenging, but one need to know how to connect this circuit. As a rule, students already have theoretical knowledge of sliding registers from theoretical subjects of logic systems.

12 Arduino and wireless devices
This topic is usually more demanding and in some cases the teacher has to increase the number of hours s/he is dealing with. It focuses mainly on Bluetooth and wifi modules, which are widely used. With the advent of the Fourth Industrial Revolution, remote management and cloud services are increasingly being used. Therefore, it is important to include in the teaching facilities through which these functions can be learned and thus acquire basic skills in this area.

13 Arduino and sensors
The first sensing elements include a temperature and humidity sensor. We are at the beginning because they belong to less demanding, but more necessary elements. Students learn the principles of functioning and the internal structure of these sensors. Then the students engage and program them. An important element are the libraries that are needed for proper sensor operation.

14 Arduino and sensing elements
Later, students learn to engage and program an infrared flame sensor and light sensor. They belong to slightly advanced components and also need a library to function properly. Students also use the knowledge of previous exercises, where specific results are displayed on the LCD.

15 Arduino and sensors
The more demanding is also the ultrasonic distance sensor HC-SR04 and RGB sensor. Students have the task of finding and using the correct libraries and connecting these sensors according to the instructions to demonstrate the activity of these elements.

16 Arduino and sensing elements
As the last, students learn to engage and use NFC (Near Field Communication) sensing elements and motion sensors correctly. These belong to the more demanding thematic ones and a teacher usually increases the number of hours s/he devotes to these elements. But they are very often used in practice and therefore we consider their inclusion in teaching and practical exercises to be indispensable.

3 EXPECTED OUTCOMES AND CONCLUSIONS
The main objective of the research, and the carried out experiment, is to propose, in terms of content and form, the optimal model of vocational training of secondary vocational school students in the field of programming lowcost control units. The benefits of the ongoing validation of various alternative approaches to teaching the programming of lowcost control units (approaches based on different ways of communicating information) for teaching practice can be defined in two ways:

- By using our suggested lowcost programming exercises, we will extend the possibilities of using new features and new content to teach technical subjects. On this level, we expect students to take a different view of programming. Based on the experience gained in validating individual alternatives, a set of recommendations will be developed for preparing students for programming these units.
- Web-based assignments can serve as an extension of teaching sources to support teaching programming at secondary schools.

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