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Programming and Simulation of Model Controls in Teaching Technics and Informatics

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Abstract: *Functional, adaptable and available systems for model programming and control are very important for the realization of teaching lessons from technical and technological school subjects. For that purpose, IT, web applications/services and simulation software for electronic circuits, microcontrollers and devices are optimal solutions. In the paper the following systems were considered and analyzed: Micro:bit and Circuits. They are directly linked to informatics and computing, thus encouraging students to acquire and develop their digital competences. Micro:bit is a small programmable computer and an online programming environment for encoding in two regimes: Block and Java Script, with created and derived examples in those operating modes. Web application Circuits serves for modeling and simulation of electrical/electronic circuits and devices. It contains electronic components (passive, active), sensors, relays, multimeter, protoboard, Arduino board. For programmable components, working modes are set via coding in affordable Arduino environment. The different models of electronic circuits and devices with LED, seven-segment display, servo motors, remote control have developed. For the listed models, the codes are written, and then realization of the virtual models functions in real time have done. With this innovative teaching approaches professional and intermediate competences by students are acquired and developed. On that way will be satisfied the required learning outcomes and fulfilled the legal frameworks in teaching technics and informatics.*

Keywords: *programming; control; simulation; technics, informatics.*

1. INTRODUCTION

Computers and microcontrollers are used to control machines, devices and systems. In order to control it, it is necessary to write specific programme codes in one of the dedicated programming environments. For this purpose, most commonly are used programming languages, such as: C, C++, C#, Java, Arduino, etc.

It is necessary to use modern technologies for the teaching process, as much as possible. In addition to computers (desktop and laptop), tablets, mobile phones and PDA are more common. Today, there are also small programmable computers for learning the basics of programming. They are designed so that learning and teaching are simple, obvious, efficient and fun. The specifics are classified into modern, innovative, and inexpensive teaching tools, which are very practical today for teaching processes in schools.

Arduino is a hardware-software computing platform called the open-source based on a simple input/output (I/O) board and development environment. Because of its simplicity and affordability, the experience of using various systems based on Arduino in classroom is very positive. It is used in teaching at different levels.

Arduino boards are easy to use and require low voltages, and therefore are installed as a flexible and accessible teaching tool for technical areas. Arduino works on different operating systems: Windows, Mac, Linux. Students and teachers use Arduino for programming, automation, robotics; or use it for the production of cheap measuring instruments in various areas of technical testing.

The Arduino platform allows reading (as voltage, current measurement) and writing (LED flashing, electromotor control, sound activation, etc.) from their digital and analog pins. This application mainly used ready-made external modules, for which libraries can be downloaded from the Internet.

There are available and specific online applications for modeling electronic circuits with Arduino boards. They have certain characteristics, with more or less options, and such simulations in real time can present and show the principle of operation of various technical and technological systems. In some of these web simulators,

multiple operations can be combined at the same time, namely to write, test, and execute generated program codes.

2. CONTROL OF TECHNICAL SYSTEMS

Connecting computers to external devices is done through ports, i.e. digital sockets. These devices can be grouped into two groups: input and output. Mechatronics is a multidisciplinary engineering discipline that includes electrical engineering, computing, mechanical engineering and automation. Today there are many models, i.e. reduced imitation of modern automated systems. Each such system consists of: software, control electronics (interfaces) and input-output parts. This is simplified present in the following figure 1, where the traffic light is given as an example of an executive part. [1]

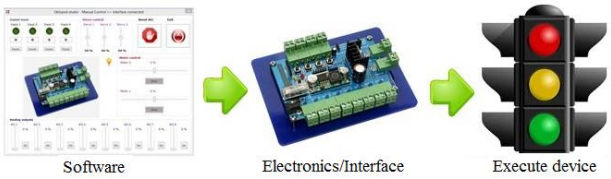

Figure 1. *Simplified control concept through the interface*

Computers have a very important application in the control process of machines, devices, processes, business systems etc. By using computer it can be controlled sound, light, mechanical and other phenomena. This is done by satellites, robots, railways, home appliances, medical devices, smart homes devices, production processes, traffic, etc.

Computers work with a binary number system, using only two elements, i.e. logical 0 and 1, which represent electrical signals (impulses). Sound, light and other analogue impulses should therefore be converted into combinations of 0 and 1, and this is done by the analog-to-digital converter (A/D). When a computer accepts data in binary form, all operations are performed exclusively with binary numbers. Lastly, the results of these operations are also combinations of logical 0 and 1, and it is necessary to convert these series of numbers through those digital-to-analog converters (D/A) to something which is intelligible people (Figure 2). [2]

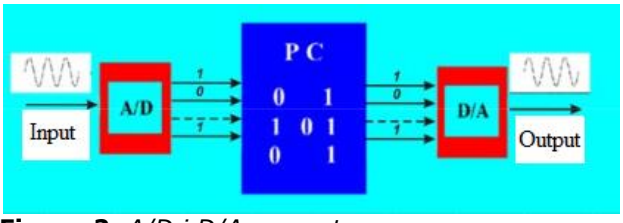

Figure 2. *A/D i D/A converters*

The models can be controlled through the appropriate interfaces. The following programming languages are used for software modeling, i.e. for coding: Visual Basic, C++, C#, Java, Arduino, Pascal.

In modern control systems, microcontrollers are indispensable elements. The microcontroller is a so called "small computer" located in one chip. It contains microprocessor, RAM memory, programmable memory, analog-to-digital converter, digital inputs and outputs, interfaces, oscillator. This chip will not work without accompanying electronics, which will provide it with regulated and precise power supply, as well as communication with the computer through which the microcontroller will be programmed. Unlike the microprocessor, which is designed for working on PC, the microcontroller is targeted for installation in various devices and systems, where it has a defined purpose, and such special computers are denoted as embedded computers. Microcontrollers are used in a variety of technical products: robots, telecommunication devices, satellites, cars, instruments, mobile phones, cameras, home appliances, etc.

3. MICRO:BIT

Micro:bit is a new product in the field of computer technology, supported by the BBC company. It has a 32-bit processor running on batteries, 25 LEDs and 2 programming switches. There are also add-ons in the form of a sensor; including a built-in compass, accelerometer, Bluetooth Smart technology, five input and output (I/O) rings, a micro USB connector (Figure 3). For the basic model the price is about 20 Euros, and those with better performance (and even more expensive) can be ordered and purchased. [3]

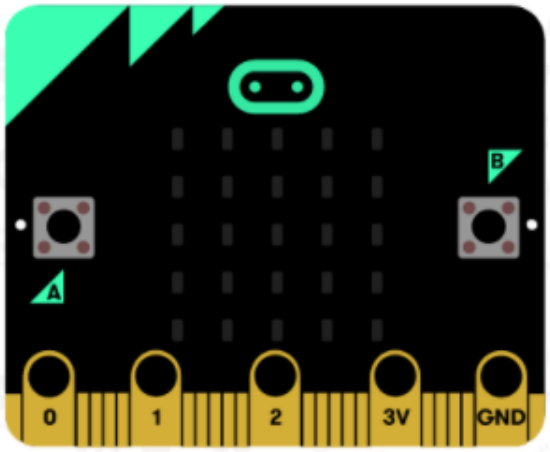

Figure 3. *Micro:bit*

Because of a simple graphical environment, programming on it is designed to be the easiest possible (for lower levels of education). However, it is also compatible with advanced programming languages, and also enables direct programming (coding) for teaching at higher levels of education. Micro:bit is a small computer, or a miniature programmable tile (size 4x5cm). Software is an application that is accessible from PC, tablet, mobile phone. Parts of the working environment are the following: simulator, commands - tools and workspace for code input (Figure 4). [4]

The simulator is located on the left side of the screen, and a virtual micro:bit device shows the execution of functions. The tools are in the middle of the screen, there are several different

categories, each containing a number of blocks, that can be dragged into the programming workspace on the right. The workspace is located on the right side of the screen and it is a program part, where the command blocks are placed or the codes themselves are written.

There are many commands in the following categories: Basic, Input, Music, Led, Radio, Loops, Logic, Variables, Math, Advanced. After entering the codes, the project can be saved and then executed in real time (response is directly visible). There are in total two options, Blocks and JavaScript, to enter the commands.

This interactive simulator provides students with instant feedback on how their program is running, and allows them to debug their code.
Blocks is graphical drag and drop code editor, understandable and intuitive. In it are entered ready commands with the possibility of certain changes in their parameters. Students new to coding can start with colored blocks that they can drag and drop onto their workspace to construct their programs.

With JavaScript, the codes are in the lines one below the other. JavaScript is a popular programming language for programming dynamic web sites, not complicated, but extremely powerful. JavaScript does not have to be run through a compiler, that reads the code into something the browser understands, but the browser effectively reads the code in the same way, and then interprets it. When students are ready, they can move into a full-featured JavaScript editor with code snippets, tooltips, and error detection to help them. [5]

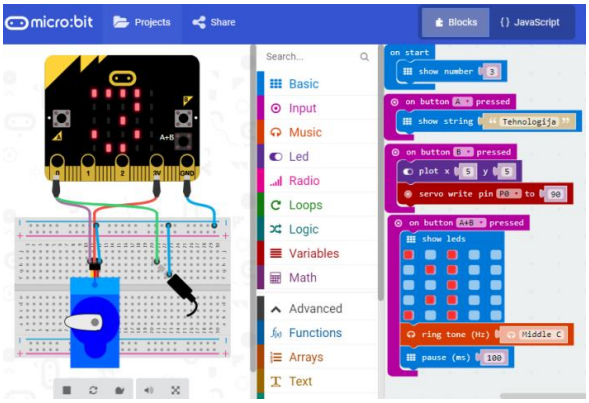

Figure 4. *Micro:bit – Blocks*

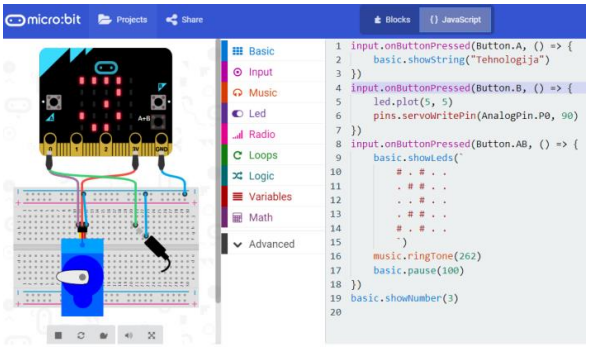

Figure 5. *Micro:bit – JavaScript*

In Figures 4 and 5 above, examples of created codes in the micro:bit are given. More precisely, they are presented the same in parts of the Blocks and JavaScript (in the images on the right). At the same time, the implementation of the mentioned control codes are visible (in the images on the left).

4. MODELING AND CODING IN THE CIRCUITS/TINKERCAD APPLICATION

Circuits is an online tool for designing projects in electrical engineering and electronics. Basically it is easy to use, free and convenient web service for simulating electric circuits in the classroom.
Formed models are automatically stored and, if necessary, quick and easy to add/delete components. It can serve to explain and present programming to students and how to connect electronic components to circuits, especially if there is no actual Arduino platform. Certain component characteristics can be easily and effectively modified as needed.

There are many components and libraries in options, which is enough to work in this environment (for 7th and 8th grade of elementary school), and even at higher levels (secondary technical schools). It has been noted that over time, this application is upgraded and expanded with additional options.

Application helps in creating electronic circuits, without the use of real components, with the option of control the programmable components (encoding). In other words, it is a virtual prototype platform that provides the ability to work in an electronic environment (Lab View) without the need to purchase and connect real components. This environment makes a lot of different components available, which we use the same way as the actual ones, with the difference that they can not cause physical damage during testing. Then it offers the ability to start creating original project, or download it from other users.

The Circuits application has the ability to debug the code, which is quite complicated on most actual models, and also has a timer during model simulation. It is so called emulator and is some kind of Arduino platform, intended for the writing, testing and executing certain specific codes. [6]

When the development of a project is completed, the program code can be transferred to the Arduino device, where it will run in the same way, as in the virtual Arduino.

The command in the considered application are: Undo, Redo, Zoom To Fit, Delete, Rotate, Share, Export.

In the Components section, there are many parts for presenting electrical/electronic elements, circuits, machines, devices. Clicking on the component it can be easily dragged on the working space. Besides of active and passive electronic components, several types of Arduino boards, there are also sensors, relays, displays, motors, measuring devices, etc. Some

components from the Circuits application in Figure 6 are shown. [6]

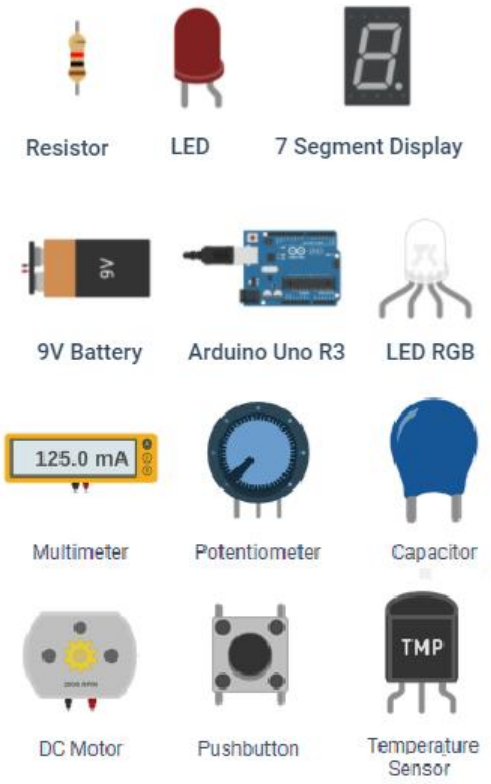

Figure 6. *Certain components in the application Circuits*

Circuits application helps students in direct realizations of electronic projects, without the use of real components, i.e. it's a virtual prototype platform, that provides the ability to use an interactive electronic environment. For programmable components, specific codes are written in order to define and control the operating modes.

Various functional electronic models were created in the Circuits application with the Arduino UNO board, the appropriate components (and conductors). The lines of codes written in the Arduino environment determine behavior, and also controlling the operations of these models, i.e. programmable components in them over time. Application is used for teaching in the field of robotics and model control by computers. During the research, the following models have been created and control (with specific coding):

- LED model
- RGB LED model
- Traffic light model
- Running light model
- Seven-segment display model
- Robotic arm model (with servo motors)
- Advertising light model with remote control (IR).

The realization of above mentioned models are clearly seen in Figures 7, 8, 9, 10, 11, 12, 13.
Circuits has a certain base of electronic components, it defines the operation modes of programmable components, allows the expression of creativity, the implementation of project oriented teaching and further learning through research by students (and also teachers).

Thus students can prototype and simulate certain circuits with Arduino code without hardware.

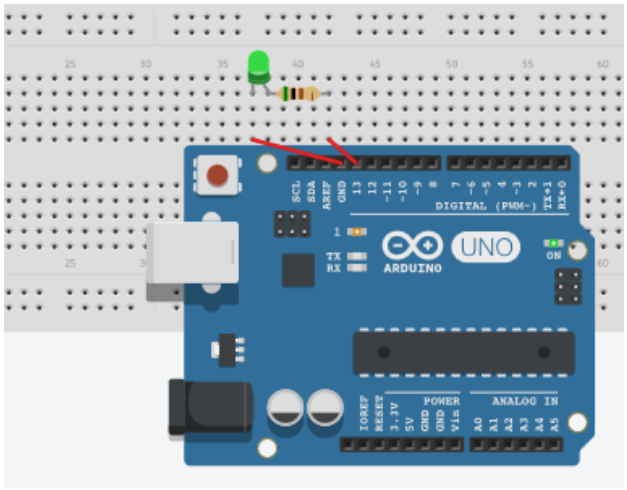

Figure 7. *LED model*

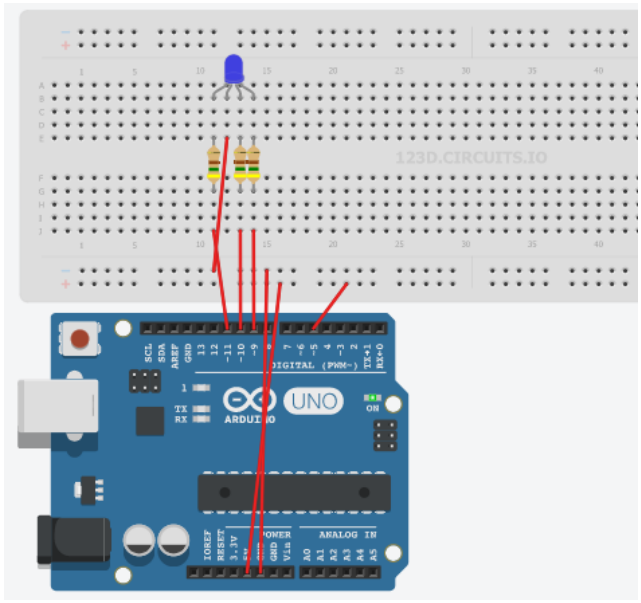

Figure 8. *RGB LED model*

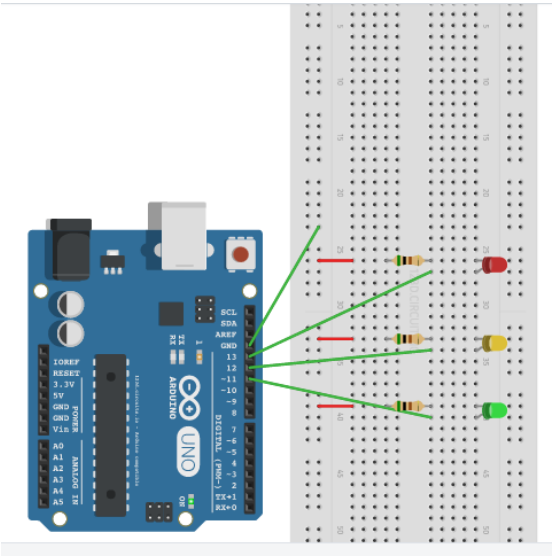

Figure 9. *Traffic light model*

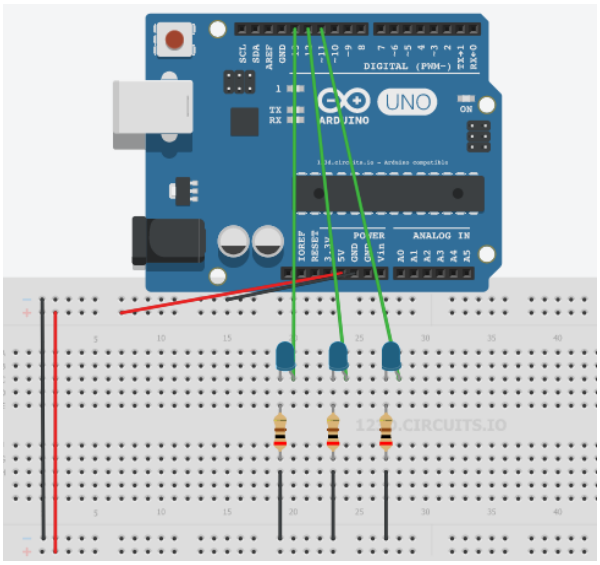

Figure 10. *Running light model*

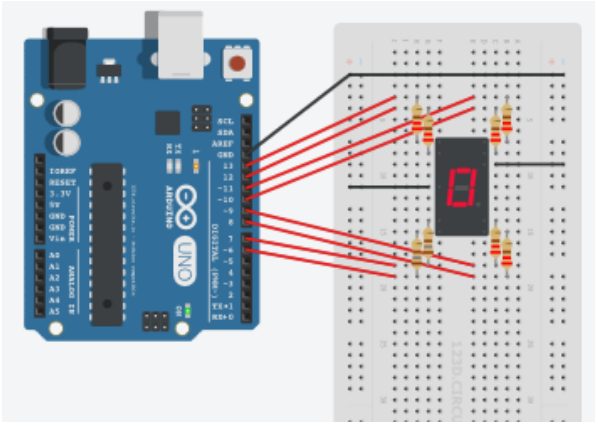

Figure 11. *Seven-segment display model*

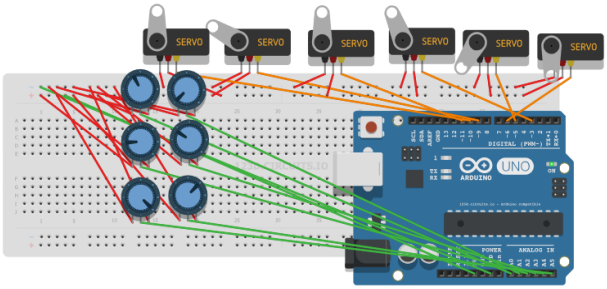

Figure 12. *Robotic arm model (with servo motors)*

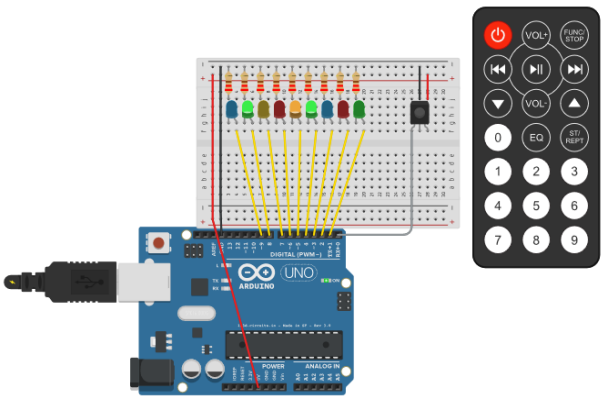

Figure 13. *Advertising light model with remote control (IR)*

5. CONCLUSION

Optimization of existing resources to achieve the necessary goals, tasks and outcomes in education is imposed today as an imperative. Teaching plans /programs, but also methods, equipments, technologies for general and professional technical and technological school subjects, must be fairly rapidly changed, innovated and adapted to require job markets and standards. IT-based learning tools become irreplaceable in teaching and learning. This paper examines the programming and control of models in the teaching technology and computing (approximately levels of primary and secondary schools). The two relative new teaching tools were considered and analyzed, i.e. Micro:bit and Circuits. Besides of that the main elements of the control system have analyzed, and the roles of microcontrollers/PC in controlling certain technical devices and systems have explained.

Micro:bit can be used as a programmable computer (hardware) and online encoding programme (software). The coding are not so complex for students. It works in two optional operating modes, i.e. Block and Java Script. As a teaching tool, it is adapted to learning the basics of programming, and visually gives quite direct views/responses of the realized control on the previous created models. Micro:bit devices can be used in a large number of school subjects that, at first glance, are not directly related to programming and thus help digitize the teaching process and encourage learning in a creative way.

The Circuits application (from the Tinkercad environment) for modeling and simulating electrical/electronic circuits is a solution for efficient teaching, with the optimal use of ICT. The application is not complex, it has a functional graphical interface, then availability online (free cost), easy to enter components on the board and certain changes in their parameters. With the model simulation, by programming (coding), and appropriate control them, the application combines the inventive approach to teaching, with innovative computing technologies, needed for modern and up-to-date education from electronics and programming.
In the paper the following models have researched and developed in Circuits: LED, RGB LED, traffic light, running light, seven-segment display, robotic arm (with servo motors) and advertising light model with remote control (IR).

These listed teaching tools make connection between curriculum from technics/technology and informatics/computer science. Teaching units from the different school subjects are complemented and functionally linked, for the better and deeper understanding technics and informatics materials, as the continuous knowledge and skills acquisitions by students.

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