IMPLEMENTING THE LABORATORY OF MICROCONTROLLERS DURING THE ERASMUS+ MOBILITY

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Abstract: *This paper presents details about the Erasmus+ mobility of two students from Belarus in Romania at the Univeristy of Pitesti. The problems of performing a mobility, the implementation of course homeworks, as well as the impact of on the educational process in the Republic of Belarus in the conditions of the COVID-19 pandemic are outlined. This paper will focus on the microcontrollers laboratory implementation in a virual learning environment.*

I. INTRODUCTION

ERASMUS+ is an educational program that helps universities to establish exchange of students, undergraduates, postgraduates and doctoral students, as well as teachers.

It is also a unique opportunity to meet children from other countries, improve the level of a foreign language and get an unforgettable experience.

The program is attended by second-year students of the university and older who are engaged in scientific research in their specialty.

You can leave for an internship only to the university with which your university has entered into an agreement on the ERASMUS + program. Staying at a foreign university under the ERASMUS + program lasts from 3 (one academic semester) to 12 months.

You can use the program several times: either as a student or as an intern. But the time spent abroad during one cycle should not exceed one year. Tuition at the host institution is free.

A program participant can receive a grant under the ERASMUS + program, which compensates for travel and accommodation costs.

Studies at the host university are either in English or in the state language. It all depends on the program.

II. EDUCATION IN BELARUS DURING THE COVID-19 PANDEMIC

The coronavirus pandemic has made adjustments in all areas of life, including education. Teachers, schoolchildren and students had to master the technologies of remote study and work. The Ministry of Science and Higher Education of Belarus has issued a recommendation guide for organizing classes in the new academic year in connection with the COVID-19 epidemic. Requirements for the organization and implementation of sanitary and anti-epidemic measures aimed at preventing the introduction, emergence and spread of COVID-19 infection are set out in Chapter 7 of the sanitary norms and rules approved by the Resolution of the Ministry of Health of the Republic of Belarus No. 37 of April 10, 2020.

However, this is just a proposal for universities, because due to its autonomy, the final decisions regarding the organization of classes are made separately by the rector of each of the universities. In this regard, everything looks different at each university. The universities of Belarus have made every effort to prepare for the new academic year in the current situation. In connection with the ongoing coronavirus pandemic, universities have developed different scenarios. For example, during the period of the spread of COVID-19 infection, a regime for organizing the

educational process is established, which provides for the observance of the principles of social distancing, including:

- division of the start and end times of shifts (training sessions, classes, breaks);
- increase, if possible, the duration of changes and the duration of shifts, including in educational institutions with a two-shift mode of operation, by at least 5 minutes, in order to conduct ventilation;
- the maximum possible separation of students when studying, living, organizing sleep, meals;
- limiting the holding of mass events in the premises of educational institutions, including using the assembly, music and sports halls, swimming pool (if any), visiting exhibitions and museums, theaters and cinemas, other general events, minimizing the number of participants and invitees with the provision of social distancing.

The most popular is the hybrid form of education – part of the classes, lectures in the form of online; part – mainly practical exercises – stationary. Some universities have completely switched to distance learning. The number of groups in which classes are held has been reduced, and the management of universities of higher educational institutions carefully monitor that the schedule does not allow gathering too many students in one place.

Also in each office there are hand sanitizers. It should be noted that online education for Belarusian higher education institutions is not at all a novelty. Universities have been actively using this method for a long time. Distance learning at the Belarusian State University of Informatics and Radioelectronics has been operating since 2002 through the electronic platform of the Electronic Learning System - SEA. The platform was created by the developers of the university, adjusted to the needs and capabilities of students of technical IT specialties - theory and practice are studied and worked out in full in the curriculum, additional experience of participation in projects and research is gained. Each university has long developed and available distance learning systems, on which different materials for teaching, presentations, tests, the ability to communicate with teachers, etc. were available.

Now these systems have been improved so that students can receive all the necessary knowledge, participate in lectures and take tests and exams. The COVID-19 pandemic also forced are organization of the rules governing the residence and use of student residences in Belarus.

Among the new rules governing accommodation, a ban has been introduced on entry to hostels by "outsiders", it is imperative to wear a mask and gloves, to maintain a distance. Also, each dorm has an isolation room, where, if necessary, a student with symptoms of coronavirus infection will be placed.

III. ERASMUS+ MOBILIY

During our mobility, all classes were held online. Our main task was to establish communication with each teacher and receive from him the necessary materials and assignments for the semester.

All students were also connected to the distance learning system, but in this system all lectures, assignments and laboratory tests were only in Romanian. During the laboratory work, we used various simulators, since it was not possible to work in specially equipped rooms due to COVID-19.

Also, each faculty was assigned a responsible person - a curator, to whom one could turn for help at any time of the day. In addition to the curators, during the entire mobility, coordinators kept in touch with us, who organized leisure time in their free time and helped with various other issues.

IV. MICROCONTROLLERS LABORATORY

In this paper we will present the design and implementation of a system that can be used for education of microcontrollers during the COVID-19.

There are several tools that can be used in a virtual microscontrollers laboratory, as outlined below.

Tinkercad Circuits Arduino is a free, simple and powerful Arduino emulator that you can use to start learning electronics and robotics. It provides a very convenient environment for writing your projects. You don't need to buy anything, download anything – everything is available online.

Wokwi is a modern Arduino online stimulator that is capable of supporting multi-file projects. To get started with the Wokwi Arduino Simulator, we can visit wokwi.com.

Fritzing is an open source initiative dedicated to helping designers, artists, researchers and hobbyists take the step from physical prototyping to real product. This software is designed to simulate the Arduino board, allowing you to design and document your Arduino and other electronic prototypes, share them with others and teach electronics in the classroom.

The UnoArduSim app is a free Arduino Uno simulator. Giving the opportunity to see the progress of the program in real time without the presence of the Arduino Uno board itself. It is intended to facilitate debugging of Arduino programs and contains a set of virtual devices that can be configured and connected to the virtual Arduino Uno.

AVR8js is an open-source Arduino simulator based on JavaScript that can run in the cloud or virtually anywhere javascript runs.

In this paper we are using the Inkerpad environment. Tinkercad is an online service now owned by Autodesk, the beast of the CAD world. Tinkercade has long been known to many as a simple and free 3D modeling learning environment. With its help, you can quite easily create your own models and send them for 3D printing. [4]

More recently, Tinkercad was able to create electronic circuits and connect them to the Arduino virtual board simulator. These critical and powerful tools can make it easy for Arduino designers to learn, design, and program new circuits.

Tinkercad was created in 2011 by Kai Backman and Mikko Mononen. The product was initially marketed as the first Web-based 3D design platform in which users could share results with each other. In 2013, the service was purchased by Autodesk and added to the product family. During all this time, within the framework of the service, more than 4 million projects have been created and published by users.

In June 2017, Autodesk decided to move some of the functionality of its other Electroinics Lab Circuits.io service, after which Tinkercad received extremely important and powerful tools that can greatly facilitate the process of learning, designing and programming new circuits for Arduino developers.

To get started, you need to get an Autocad account. Registration at Tinkercad is absolutely free. You need to go to the site and follow the simple steps to register.

After the registration stage, a list of services and a list of projects are visible on the main page on the left. The navigation is very simple, although some of the links do not look very noticeable, but figuring out what's what is easy. By selecting an item on the left, a list of corresponding objects is visible on the right. For the Circuits section, these objects will be schematics and sketches.

To create a project, you must click the "Create project" button located under the list of projects. A project with the name of the Project N type will be created. By clicking on it, it switches to the mode of viewing the list of schemes included in this project. There you can also change the properties of the project (including the name) by clicking on the corresponding icon immediately below the name.

There are two ways to create a new schema in Tinkercad:

• in the menu on the left, select Circuits and on the right above the list of circuits, select the Create new Circuit command. The new schema will be created outside of any project;

• create a schematic in a specific project. To do this, you must first go to the project window, and then click on the "Create" button above the list. A list of circuit types will appear, select Circuit. The created circuit will be available in this list and in the list of all projects in the Circuits menu.

After executing the command, the circuit editing mode opens without entering the name. The name for the schema is generated automatically.

• To change the name of a circuit and edit its properties, go to the mode of viewing the list of circuits, hover over the area with the name of the circuit and click on the "Settings" icon. A window will open in which you can edit the parameters.

• To delete a scheme, select the "Delete" command in the settings in the same mode.

• To view a summary of the diagram, just click on it.

• To switch to the editing mode, you need to move the mouse cursor and select the appeared command "Change".

All changes in the process of editing the circuit are saved automatically.

Clicking on the "Change" command opens the scheme editing mode. With a convenient and simple graphical interface, you can draw the desired electrical circuit. You can select, move objects, delete them in the usual way using the mouse.

In edit mode, the service window is divided into two halves: at the bottom there is a panel with tabs – this is a component library. Above it is the area for visual editing of the circuit with the toolbar and the space on which the circuit will be placed.

The main commands are located on the toolbar in the upper left part:

• rotate the element;
• delete;
• scale to fit the screen;
• cancellation;
• repeat.

Buttons on the right side of the panel:

• display the programming and debugging panel;
• display the component library panel;
• run the circuit simulator;
• export to Eagle .brd;
• share.

In general, the interface is quite simple, not overloaded with unnecessary elements and is intuitive. Almost any operation can be performed "by touch".

In most cases, the following algorithm of actions is performed to work with Arduino projects:

1. create a new scheme or open an existing one for editing;

2. using the visual editor, create a circuit (in our case, with the Arduino Uno board turned on);

3. prepare a sketch in the code editor and load it into the virtual controller;

4. start the simulation mode, in which the board is virtually connected to the power supply and the circuit starts working. We enter the initial data for the sensors and observe the reaction of the circuit, both visually and on the virtual port monitor inside the service itself.

V.LABORATORY IMPLEMENTATION

We will assume that the project has already been created in the way described above.

After we click on the Create button, choosing the type – Circuit. After this step, a visual editing environment opens, in which we can both draw a diagram and write and debug an arduino sketch.

When creating a schema, it is necessary to perform the following procedure:

• select the required components from the component library at the bottom of the screen and place them in the editor field;

• connect the components using virtual wires, drawing them with the mouse;

• edit the parameters of the components (for example, the resistance value of the resistors or the color of the wires).

Selecting from a library is quite simple. The list of items is at the bottom. Having selected an element, you need to click on it, then move it to the desired place on the diagram and click again. The component list box can be hidden or shown by clicking the Components radio button in the toolbar.

There are many ready-made elements available for work, from a resistor and a battery to Arduino modules. For ease of navigation, all elements are divided into three tabs:

- Basic Components;
- All Components;
- Starters.

Having opened the third tab – Starters, you can see that the creators of the service have prepared several ready-made schemes that can be immediately loaded into the project and edited at your discretion. Find any circuit with Arduino in the list and click on it. After a second click, the schematic elements will be placed in the editing area. As an example, we have selected a three-button musical instrument scheme. After placing it, we will see the following on the screen (figure 1).

If the circuit does not fit the screen, you can scale it (zoom button on the toolbar).

By clicking on the arduino connector or the legs of the electronic components, you can "solder" a wire to it, which, with mouse clicks, stretches across the entire board to the desired point.

The corners of the wire are nicely rounded, it is possible to align the wire vertically or horizontally (the appearance of blue lines will tell us the vertical and the horizon, respectively). To cancel the installation of the wire, you need to press Esc or click on the corresponding icon on the toolbar with the mouse.

By clicking on a component, we can edit its properties. All tools for editing code become available after switching to the appropriate mode by clicking on the "Code Editor" button in the top panel.

In the code editing mode, the following options are available to us:

• load the sketch into the "virtual controller" and run the simulator;

• switching to a visual code editor like Scratch;

• switching to the text editor of the code;

• connection of libraries;

• download the code to your computer as a file with the .ino extension (sketch arduino);

• start a debugger with the ability to create breakpoints and monitor the states of variables;

• show or hide the monitor window.

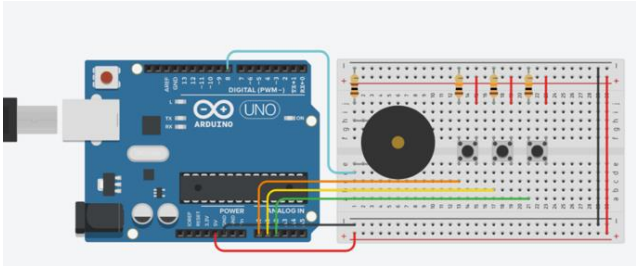

Fig.1 The system structure

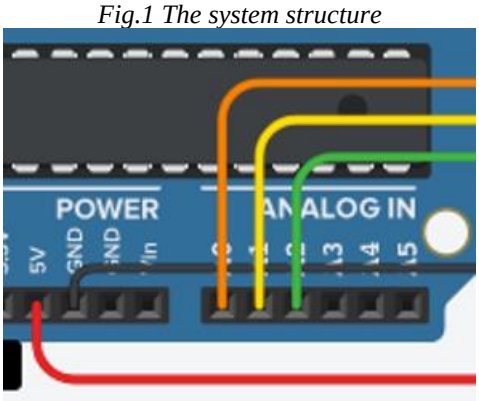

Fig.2 Connecting process in Tinkercad

```
15 void setup()
16 {
17   pinMode(A0, INPUT);
18   pinMode(8, OUTPUT);
19   pinMode(A1, INPUT);
20   pinMode(A2, INPUT);
21 }
22
23 void loop()
24 {
25   // if button press on A0 is detected
26   if (digitalRead(A0) == HIGH) {
27     tone(8, 440, 100); // play tone 57 (A4 = 440 Hz)
28   }
29   // if button press on A1 is detected
30   if (digitalRead(A1) == HIGH) {
31     tone(8, 494, 100); // play tone 59 (B4 = 494 Hz)
32   }
```

Fig.3 Example coding process

In fact, we have before us a full-fledged development environment, which has a modest, but quite sufficient set of tools for such cases. And the presence of a visual mode and debugging mechanisms in one environment makes this service truly unique.

There are two ways to run the simulator. The first is to click on the «Start Simulation» button

in the top panel. The second is to use the Load button and run in code editing mode.

In both cases, to stop the simulator, you just need to press the top button again (in the simulation mode, the inscription will change to "Stop Simulation").

During the simulation the same activities happen as when connecting power to a real circuit. The lights are on, sounds are emitted from the piezoelectric emitter, the motors are spinning. You can track the current indicators (voltage, current) using monitoring tools. And you can independently create external signals by supplying the necessary values to the sensors and then monitor the program's reaction. For example, you can use the mouse to set the location of the object to the distance sensor, the illumination value for the photoresistor, and turn the potentiometer knob. Such elements as LCD display also work great – we will see the displayed information directly on the screen of the visual component.

VI. CONCLUSIONS

Obviously, the virtual environment will never replace real projects and a real engineer is simply obliged to implement his ideas “on hardware”. But here is the opportunity to visualize ideas, throw in possible variants of the scheme and debug the work of the sketch, even without the presence of hardware, in any place where there is an Internet – it costs a lot.

In conclusion of the article about Implementing the laboratory of Microcontrollers during the Erasmus + mobility, it ia necessary to highlight the key features of this development environment for education in the context of the COVID-19 pandemic: visual circuit editor, visual and text code editors, debug mode, circuit simulation mode, the ability to export the resulting sketches and electrical diagrams into real projects. Individually, each of these features may be better implemented in other powerful tools, but collectively, and even in the form of a user-friendly, easy-to-learn web service, they make Tinkercad extremely useful.

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