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FORMATION OF STUDENTS' INVENTIVE SKILLS IN ROBOTICS THROUGH ONLINE TRAINING

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Abstract

The purpose of the study is to test the effectiveness of the students' inventive skills formation in online training in the basics of circuit engineering and robotics. The TinkerCAD Circuits modelling system is used for practical mastering of the circuit engineering principles, lecture and consulting events are implemented by tools of online communication Skype and YouTube broadcasts. The training is based on the principles of gradual complication of tasks and the teaching of the invention. The study was conducted at Sholom-Aleichem Priamursky State University in the 2020-2021 academic year. Two groups were selected for the study, the control group studied the basics of circuit design using prepared tasks of different levels, the experimental group used the TinkerCAD modelling system for training to form inventive skills. The results of the study showed the technique's effectiveness: the increase in the control group was only 13 per cent, while in the experimental group there was an increase of 42 per cent. During the study, an increase in students' interest in the performance of work was noted, attempts to independently improve working devices. Further improvement of the methodology may be associated with the adaptation of the developed system to an expanded range of training areas.

Keywords: Circuit engineering, circuit modelling, invention, online training, robotics, TinkerCAD

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1. Introduction

The changes that have occurred and are taking place in modern higher education are increasingly forcing teachers to use not only various educational environments but also tools for the implementation of various kinds of online workshops. This seriously distinguishes this approach from the previous stage, in which everything was limited to the use of online communication tools (Yang et al., 2021), and research data showed outright problems with the introduction of new tools in training (Coman et al., 2020). Of course, in the conditions of active development of robotics and Internet of Things technology, there are a large number of already developed environments for different controllers. In a particular case, when using the Arduino controller system, the most suitable of them is the Autodesk TinkerCAD Circuits system (hereinafter referred to as TinkerCAD) (TinkerCAD, 2021), recognized by many developers in the field of robotics as a preliminary modelling tool (Mohapatra et al., 2020).

Various systems are often used for teaching circuit engineering and robotics, which, combined according to the modular principle, are able to ensure the effectiveness of the educational process (Shalannanda, 2020). At the same time, instrumental systems such as TinkerCAD are used for many implementations, both by education levels (Moreno-Vera, et al., 2018) and by areas of use (Cullen, 2020). As one of the modules, TinkerCAD is well integrated into the educational process on the principle of ubiquitous learning (Twidale, 2010).

On the other hand, the formation of inventive skills of students with the help of various kinds of simulators has already proven itself well (Bujdosó et al., 2017). The essence of the successful development of such skills mainly lies in the correct selection of tasks (Arciszewski, 2016). In this study, among other things, there'll be a conversation about overcoming possible problems associated with the transfer of activities in circuit engineering and robotics from real components to the simulated behaviour of devices.

2. Problem Statement

In the current epidemiological situation, universities are still forced to at least partially use forms of indirect education (with partial groups quarantined or old teachers' situations), which has led to several difficulties. They were concerned with both the problems of finding the optimal tools for organizing online classes and the modification of materials and tasks for distance learning. Under these conditions, it was decided to assemble a set of educational tools that allow organizing communication with student groups in a short time, implementing practical tasks and testing students' knowledge.

As a result of the analysis, it was revealed that there is an invariant set of educational tools for any training (Kidd, 2020; Liu et al., 2020; Piteira et al., 2018; Smyk et al., 2020; Watanobe et al., 2020). Their usage has a fairly long history, plus over the past year, a large number of educational platforms and applications have been developed that can be applied or adapted to the educational process. The analysis showed that the three main forms of classes can generally be implemented as follows:

1. Lectures: text with possible hypertext, video with timestamps, audio recording.
2. Practical tasks in a wide variety, depending on the subject taught and the approach.
3. A set of test tasks: training tests, tests for passing control points, control tests.

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The invention is generally quite a complex topic. There are fundamental discoveries, theoretical propositions that have been developed for a long time and from theoretical positions (with disregard for special cases). At the heart of the invention is a specific situation that needs to be solved or a problem that pushes to create something fundamentally new. In this case, when all factors are taken into account, an invention appears that allows solving the problem or part of it. For example, when a large number of graphic elements appeared when working with a computer, there was a problem with accessing these elements, as a result of which a manipulator was created, which we know as a computer mouse, a device that has become the most convenient tools of interacting with a computer for many years. Now the mouse is inferior in this only to the sensor.

It is necessary to understand that the inventor, as a rule, does not create something fundamentally new, he uses the available tools and means to create a new product that solves a problem of interest to him. Another approach to inventing is to create a device similar to an existing one that significantly surpasses it, for example, in the cheapness of production or use, or uses a different principle in its work. For example, you can look at the invention of various engines for technology, the principle of operation is similar, but the nature of the movement itself is sometimes different.

Due to certain historical reasons, the invention in Russia and the Birobidzhan, in particular, was practically reduced to negligible figures. At the moment, the primary task in this direction is to teach schoolchildren and students the basics, not only with a technical component, but also motivation, initiative and other, mostly psychological aspects of the invention.

3. Research Questions

When describing the current experiment, the focus will go on the principle of organizing practical tasks in the TinkerCAD system, the remaining elements have a broad description in the sources presented.

When implementing the system, a concept appears - an approach to learning. In this sense, three types of approaches are of interest:

1. Cognitive, in which learning takes place from the position of "what if?".
2. Inductive, in which learning uses the process "from the particular to the general".
3. Integrated, in which cognition is combined with induction.

In the learning process, to achieve educational results, it is necessary to combine the application of the student's general experience to a particular situation in combination with curiosity and experimentation. By this approach, the very form and content of the tasks is built, which has the following features:

1. The task is based on the existing knowledge base, at least partially (in case of lack of knowledge, the closest analogue is selected, for example, an LED light bulb).
2. It creates the purpose of the preparatory steps for the implementation of the principle of gradual complication of the material (for example, when using LEDs, the gradual increase of their number and collaboration, transition to the devices that control them, etc.).
3. There is a gradual relief of "hand on the shoulder", which reduces the number of unambiguous instructions that added freedom of action of the student as the complexity of the material.

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Thus, when studying circuit engineering, on the one hand, the student gets used to the elements and devices with which he works, gaining confidence in his actions, on the other hand, the range of possibilities is expanding, consisting in the application of software and technical approaches to instrumentation. Due to the appearance of more free instructions and step-by-step execution of tasks, the assembled devices eventually acquire the individuality of the person creating them. The same can be said about the implementation of the program code. Thus, an individualized learning trajectory can be implemented.

In the case of distance learning, an independent part is mainly used, which is quite difficult to control and "target" the student. For face-to-face training in circuit engineering and robotics, specific Arduino kits are usually used, in a remote format, it is better to use simulation systems such as TinkerCAD. The TinkerCAD system has a large set of tools both for implementing the process of modelling schemes and projects and for organizing the work of students and their control.

The simplest control method in Arduino is to create a class (Figure 1).

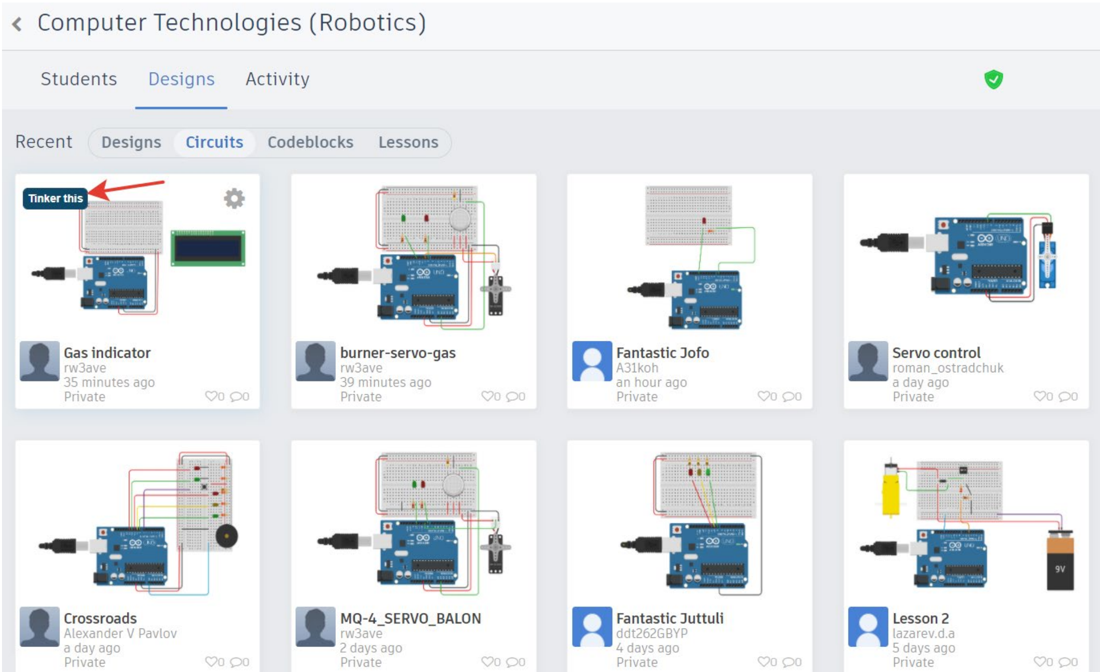

Figure 1. Page demonstrating class device status

The list indicates the devices with the signatures of the students. Also, it describes the current condition of the devices. Every device can be opened, for example, to add a signature or an explanation of his mistake, and click the "Edit" button that pops up on the image of his work. In addition, having a list of already added students of the group, the teacher can go to their profile and view (and edit) their projects. The entire access system is similar to a workbook, to which there is access even during the student's work, although for more or less online tracking mode, it is necessary either to use systems such as Zoom and Skype or sometimes refresh the page.

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The problem is that the use of training tools in the system is quite cumbersome, and the system itself takes a long time to load, so it is better to use another platform, for example, a social network, to organize information hub.

The usual structure of the lesson creates the following pace of study: a maximum of 15-20 minutes for theory, followed by practice. If possible, in a distant mode, it is necessary to use live communication (using Zoom and Skype) to explain theoretical points and then proceed to monitor and individual consultation using TinkerCAD and these tools. Figure 2 shows an example of a circuit created by students as a result of a lesson.

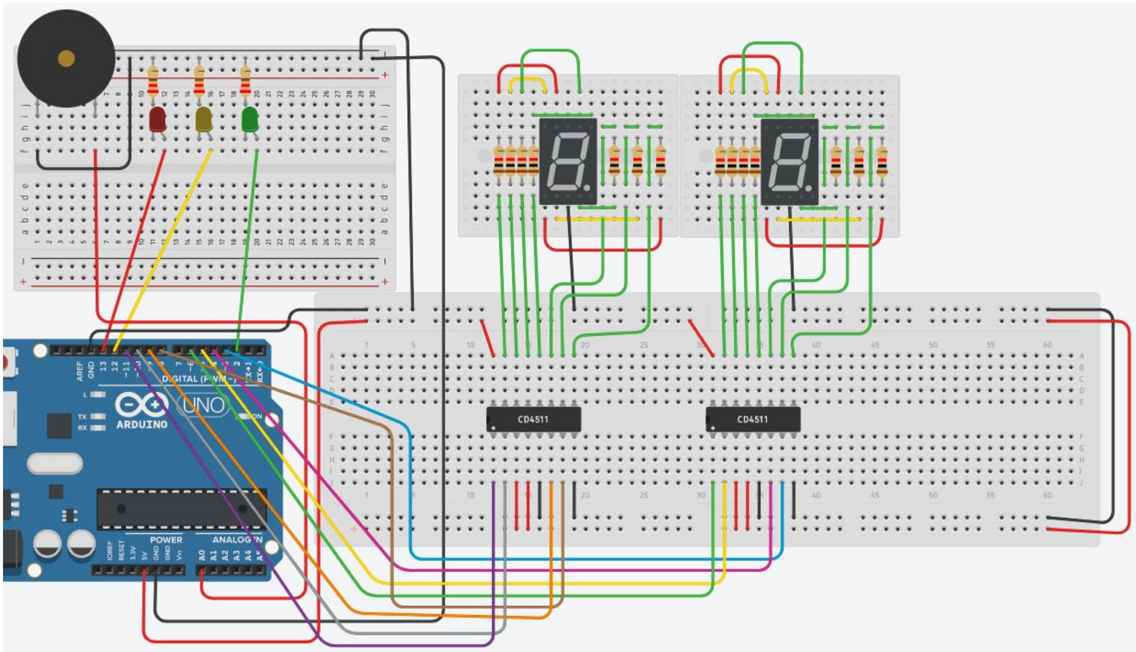

Figure 2. Example of the circuit in TinkerCAD modelling system

Thus, if we talk about distant learning tools for circuit engineering and robotics, they are as follows:

1. For solving organizational issues such as schedules, scores, lists of groups, training materials etc. more suitable tools are the community in a social network, or learning environment on the format of MOOC (massive open online courses such as courses in Stepik, Coursera, Udemy etc.

2. For establishing "live" communication tools of Internet communication, such as Zoom and Skype.

3. For the organization of a workspace, the TinkerCAD Circuits modelling system.

4. For the implementation of test materials, any tools of testing and evaluation, for example, Google forms, MOOC system tools.

To the previous point, it should be added that the knowledge test is needed not so much to quantify the student's work, but to understand what he did not learn in the learning process, respectively, with these results, you can either adjust further training or conduct individual work.

4. Purpose of the Study

The purpose of this work is to study the effectiveness of teaching students of the study direction "Electric Power and Electrical Engineering" in the field of circuit engineering and the basics of robotics using TinkerCAD Circuits as an online modelling tool. The study will evaluate the application of the developed system of tasks for the formation of inventive qualities of students.

5. Research Methods

The test proving the effectiveness of using the developed tasks system for the formation of inventive skills was conducted during the fall semester of the 2020-2021 academic year, training was organized within the discipline "Computer Technology". The Sholom-Aleichem Priamursky State University was the experimental base of the study. As an experiment, a first-year group of the direction "Electric power and electrical engineering" was selected. The experiment involved 30 students in the experimental group and 38 students in the control group. The control group was trained with the support of interactive learning tools. The experimental group was trained in an online learning environment using the following tools:

1. The VKontakte social network community as an information and communication node.
2. The Autodesk TinkerCAD Circuits system as a circuit and robotics modelling environment.
3. The Google Forms system for conducting training, intermediate and control tests (it was also used for the control group).
4. The YouTube platform for the exhibition of video materials on the discipline.
5. The Skype platform for organizing a coordinating centre for working with students.

Training with the use of interactive tools to test their effectiveness took place in three stages: preparatory, procedural and control.

At the preparatory stage, entrance testing was conducted for each group of students, the tests were compiled based on the subsequent material to assess the already existing competence baggage. After that, work was carried out to teach students how to use the tools they will work with, including the TinkerCAD system. At the procedural stage, the learning process was carried out, the features of which are indicated above. At the control stage, a final assessment was carried out, which made it possible to determine quantitative changes in the learning process. Technically, both the input and final testing were carried out using the Google Forms platform, the questions for both groups were identical.

6. Findings

During the experiment when assessing knowledge and skills, a one-hundred-point scale was used. Students' inventive achievements were evaluated at the beginning and the end of the course. According to the test results, all students were divided into three groups according to their skill level: low (less than 33 points), medium (34-66 points) and high (more than 67 points). The results of the study showed the effectiveness of the technique used: the increase in the control group was only 13 per cent, while in the experimental group there was an increase of 42 per cent. During the study, an increase in the interest of students in the performance of work attempts to independently improve working devices were noted. Consultations with students of the experimental group show a significant increase in interest on the one hand, on the other hand, difficulties arise in gradually gaining creative freedom in the implementation of devices. In general, we can say that the creation of conditions for independent productive work in the field of circuit engineering and robotics has had a positive impact on the students' performance. Based on visual analysis, it can be concluded that they have become more open, feel more confident in a situation of uncertainty, which is not evident in the students of the control group. The results of the study are shown in Figure 3.

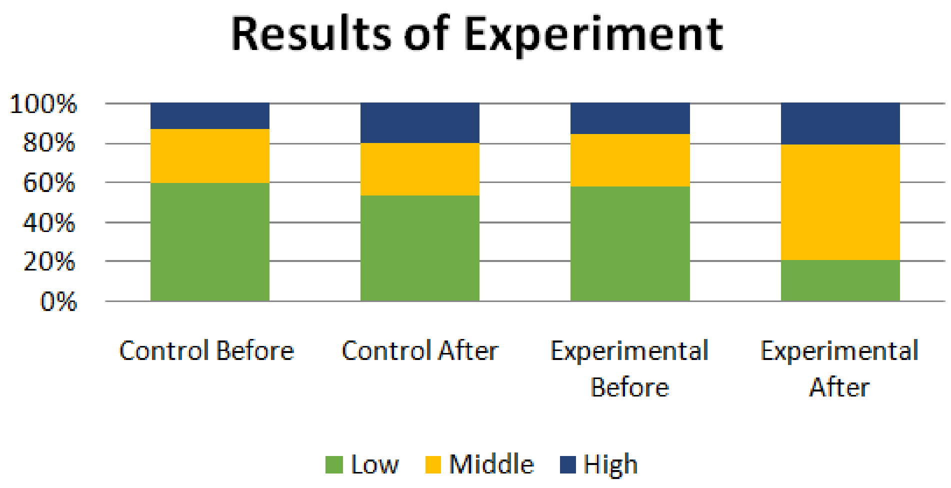

Figure 3. findings in the control and experimental groups

7. Conclusion

The use of the developed tasks system with TinkerCAD as a modelling tool for teaching students of the study direction "Electric Power and Electrical Engineering" has shown its effectiveness. The main feature is that no additional software or technical training is required for its use, that is, the modelling system is quite easily integrated into the concept of ubiquitous learning. Further improvement may be associated with the technical design of remote laboratories in circuit engineering and robotics, as well as with the deepening of the invention theory in conjunction with the use of project and team activities. Also, they may be associated with the adaptation of the developed system to an expanded range of training areas.

References

Arciszewski, T. (2016). *Inventive engineering: Knowledge and skills for creative engineers*. CRC Press.

Bujdosó, G., Novac, O. C., & Szimkovics, T. (2017). Developing cognitive processes for improving inventive thinking in system development using a collaborative virtual reality system. *8th IEEE international conference on cognitive infocommunications (coginfocom),* 000079-000084. https://doi.org/10.1109/CogInfoCom.2017.8268220

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Coman, C. Țîru L.G., Meseșan-Schmitz L., Stanciu C., & Bularca M. C. (2020). Online teaching and learning in higher education during the coronavirus pandemic: students' perspective. *Sustainability, 12*(24), 10367. https://doi.org/10.3390/su122410367

Cullen, C. (2020). *Learn Audio Electronics with Arduino: Practical Audio Circuits with Arduino Control*. Focal Press.

Kidd, S. (2020). Tools for communication and interaction in online mathematics teaching and learning. *In Teaching and Learning Mathematics Online,* 163-188.

Liu, Z. Y., Lomovtseva N., & Korobeynikova E. (2020). Online learning platforms: Reconstructing modern higher education. *International Journal of Emerging Technologies in Learning (iJET), 15*(13), 4-21.

Mohapatra, B. N., Mohapatra, R. K., Jagdhane, V., Ajay, C. A., Sherka, S. S., & Phadtare, V. S. (2020). Smart Performance of Virtual Simulation Experiments Through Arduino Tinkercad Circuits. *Perspectives in Communication, Embedded-systems and Signal-processing-PiCES, 4*(7), *157-160.* https://doi.org/10.5281/zenodo.4249073

Moreno-Vera, F., Leon Vera, L., Guizado, J., & Vera, M. (2018). A comparison of the adaptive behavior from kids to adults to learn Block Programming. *Conference: (ACE) Asian Conference on Education At: Tokyo, Japan.* http://ceur-ws.org/Vol-2193/paper13.pdf

Piteira, M., Costa C. J., & Aparicio M. (2018). Computer programming learning: how to apply gamification on online courses? *Journal of Information Systems Engineering and Management, 3*(2), 11. https://doi.org/11. 10.20897/jisem.201811

Shalannanda, W. (2020). Digital Logic Design Laboratory using Autodesk Tinkercad and Google Classroom. *14th International Conference on Telecommunication Systems, Services, and Applications (TSSA),* 1-5. https://doi.org/10.1109/TSSA51342.2020.9310842

Smyk, A. F., Tkacheva T. M., & Portnov Y. A. (2020). New digital technologies of training in the transport education. *IOP Conference Series: Materials Science and Engineering, 832*(1), 012068. https://doi.org/10.1088/1757-899X/832/1/012068

Tinkercad – *free online collection of software tools.* (2021). https://www.tinkercad.com

Twidale, M. B. (2010). From ubiquitous computing to ubiquitous learning. In B. Cope, & M. Kalantzis (Eds.), *Ubiquitous Learning* (pp. 72-89). University of Illinois Press. https://www.jstor.org/stable/10.5406/j.ctt1xcnks.10

Watanobe, Y., Intisar, C., Cortez, R., & Vazhenin, A. (2020). Next-Generation Programming Learning Platform: Architecture and Challenges. *SHS Web of Conferences, 77*, 01004. https://doi.org/10.1051/shsconf/20207701004

Yang, H., Hsiao, T.-C., Zhu, K., Yang, Y., & Guo, L. (2021). An Exploration of Online Teaching Based on Arduino Virtual Simulation Experiments. *IEEE 3rd Eurasia Conference on Biomedical Engineering, Healthcare and Sustainability (ECBIOS),* 126-128. https://doi.org/10.1109/ECBIOS51820.2021.9510339