

Cloud resources use for students' project activities

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Abstract. The modern educational system proclaims learning aimed at acquiring practical skills and based on the activity approach. Educational research projects are the necessary component of curricula in physics, computer science, biology and chemistry. There is a problem of specialized equipment and facilities using for the implementation of such projects in distance learning. Therefore, the issue of cloud resources using for distance learning organization in robotics is relevant. The article presents a brief overview of the current state of projects development in Ukrainian schools and approaches used in foreign educational institutions in teaching robotics distantly. The article describes the stages of robotics projects development such as organizational, communicative, project work, summarizing. The peculiarities of the stages in distance learning and the possibilities of cloud technologies in robotics are also considered. The authors' experience in projects developing in this environment for students and future teachers is described.

Keywords: project training, cloud technologies, robotics, Tinkercad

1. Introduction

Due to the pandemic all educational institutions have to transfer the activities in online and conduct distantly [6, 8, 13, 40, 44, 50, 57]. Cloud interaction tools, especially visual communication, have become relevant. Interaction during such classes in group projects or events has its own specifics. In particular, a survey [20] conducted among 3,000 students about online learning found that most students were dissatisfied with communication during large-scale events or group projects. The authors advise not to carry out projects distantly. But the application of cloud technologies in educational activities and developing of new ways of providing, processing, producing and storing information will help develop an environment for cooperation and new projects [5, 21, 24, 32–34, 41]. Cloud technologies will transform the educational process and apply new methods and techniques taking into account the use of technologies in educational and extracurricular activities [22, 25, 36, 53, 56, 59, 61].

There are some difficulties in conducting laboratories and practical works for certain specialities. They require special equipment, facilities, devices or reagents. For example, to implement robotics projects requires electronic equipment, elements of electronic circuits. There is a problem of cloud resources using that will help students in performing laboratory and practical work, calculation projects in robotics.

Educational robotics is a new trend in education because it has great practical significance in the use of robots and robotic devices in the modern world. But despite the benefits of

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robotics classes, there is still no consensus on its place in the education system. Some teachers implement it in the educational process and use it directly in lessons. Some schools create facultative (courses) classes in robotics. Extracurricular robotics classes in the non-formal education system have become popular in Ukraine. There is no such separate subject as robotics in school curricula. Its educational opportunities are still poorly understood and not all teachers are ready to conduct such classes. In distance learning it becomes problematic to conduct such classes, the availability of components and electronic devices is critical. Thus, these factors lead to decreasing the number of children involved in robotics and a gradual loss of interest. Therefore, today it is an important task to adapt robotics classes to the distance format, as well as to support teachers who use educational robotics in the educational process.

The purpose of our work is to identify and describe the possibilities and methodological features of cloud resources to organize the robotics projects developing distantly.

2. Related works

Distance learning is a popular and well-developed topic. There are a lot of researches into the capabilities of distance learning systems, such as Moodle. The authors consider the tools of distance platforms, ways of classes organizing, types of work and communication forms in distance learning [43, 51]. In Ukraine, there are scientific schools that explore the possibilities of distance education and the principles of its organization. Researches of Bobyliev and Vihrova [4], Franchuk and Prydacha [9], Havrilova et al. [15], Hniedkova [16] Kozlovsky and Kravtsov [26], Kravtsova, Kaminska and Kravtsov [27], Kukhareenko and Oleinik [28], Kushnir et al. [30], Lénárt [31], Petrenko et al. [39], Polhun et al. [40], Prokhorov et al. [42], Shokaliuk et al. [45], Syvyi et al. [48], Tarasov et al. [49], Vakaliuk et al. [54], Yahupov, Kyva and Zaselskiy [62], Zinovieva et al. [63, 64] and others devoted to development of distance learning methodologies and distance learning systems.

But classes in robotics have the peculiarities. The classes are practice-oriented. Existing examples of robotics introduction in the educational process show the practical side of integration of practical activities and knowledge acquiring process. Ventä-Olkkonen et al. [58] demonstrate aspects that should be considered at conducting practice-oriented researches, and point out gaps in current understanding of the practice. The authors emphasize that existing researches are focused on theoretical learning but not very practice-oriented. They support the idea of “nurture durable making practices that become weaved into the fabric of everyday life” and emphasize the importance of material aspects: the tools and equipment, if available in the longer run, capture and transmit aspects of the practice.

So, it is important to make a detailed description of cloud technologies possibilities in the practical activities.

Bekker et al. [3] use Reflective Design-based Learning (RDBL) framework, which extends the existing Design-based Learning (DBL) model. Framework includes project characteristics, design-elements, teacher’s role, assessment and social context. As methods were used frequently switching between design activities and reflecting on action at switching between activities. Authors note “the RTDP is intended for university-level students, and provides a high degree of freedom in how they go through the design process. More structure is needed for younger

pupils, at least at first, to guide them through the design process”. As tools were used various existing toolkits, such as Makey Makey, Circuit Scribe, PicoBoard, Lego WeDo and little Bits.

Chu et al. [7] considering the problem of Making practice say that “making is poised to become a generalized rather than a specialized practice, essentially literacy”. They describe the practice of electronic devices development using the Arduino microcontroller board and the ArduBlockly interface (a block-based visual programming interface).

The paper [35] deals with the remote path control of the motion of mobile robot. They give example of Automatic Control Telelab (has been developed in Siena) to support the distance learning of mobile robot control. It describes the developed remote experiments based on well-known software environment, such as MATLAB, Simulink and LabVIEW.

Project training of students in technology in the modern world acquires a new meaning [2, 10, 12, 17–19, 38, 46, 60]. There is a growing interest in robotics not only among children but also among teachers who are trying to apply new methods and technologies in the professional activities. Strutynska [47] identifies the following different types of distance learning in educational robotics: distance learning courses, MOOC, webinars and video resources, thematic channels on YouTube, thematic groups of social networks, online emulators of robotic platforms, virtual laboratories, blogs, and electronic manuals. The article also lists the resources that can be used for these types of training. Goncharenko et al. [11] presents an integrative study of robotics in summer intensive courses, a program for the study of integrated topics in physics and programming. Alyeksyeyeva, Horbatiuk and Antonenko [1] discusses some practical aspects of using the Arduino platform in professional training of computer specialists.

The problem of projects developments in robotic systems in Ukraine is quite new. Only one report on this topic was presented during the 2019 Cloud Technology Conference [23]. In the scientific works of Ukrainian scientists, this topic is presented in separate publications. For example, Tulenkov et al. [52] describes the features of the remote laboratories usage as an open online resource for engineering education are considered. In [55], we described the stages of robotics projects development and cloud resources that can be applied at these stages. The issue of the possibilities of cloud technologies for the organization of distance learning in robotics is not sufficiently covered in scientific publications. Therefore, this issue is relevant and will be described.

3. Results

Distance classes in robotics require effective organization of the educational process. It is due to the peculiarities of the performed activity: research, developing of model description of robotic systems, organization of experimental activities, statistical processing of empirical data etc. The study of robotics training showed the project activity has stages [55]:

1. *Organizational* – acquaintance with the topic, definition of goals and objectives. In the organization of environmental research and analysis of empirical data, it is necessary to provide a distance course in robotics with tools that effectively help: conduct researches, develop models of systems describing, organize experimental activities, conduct statistical processing of empirical data. Research of theory and practice can be linked through the use of simulators and virtual labs.

2. *Communicative* – determining the sources of information, ways to collect and analyze information, building of solution, determining the final product of the project, developing special interactive sections of the course, instructions on how to search information. The course can include dynamic links to databases. It is possible quickly and efficiently to find the material.
3. *Work on the project* – this stage is determined by the practical orientation, and requires specialized equipment and tools. It is also necessary to use specialized programs, technologies, in particular, robotic, programming environments; selections of technical means that best conform to the solution of professional tasks.
4. *Summing up* – feedback is a prerequisite for successful learning; the course should provide constant communication about the performed tasks and the results of actions. It allows students to evaluate the results of their work and be more motivated for further study. Assessment should include measurable assessment forms of content understanding, determination whether the student has achieved the desired competencies [14?]. One example is the use of student assessment by other students, followed by the publication of reviews and discussion. It helps critically to comprehend the evaluation criteria and the presented material, as well as to evaluate one's own achievements [29].

In general, all stages can be implemented on a distance learning platform, such as Moodle or Google Classroom. But the stage on the project requires special means. In the article [58] the review of 45 publications on the organization of students' practical activity is made. The authors of the article concluded in most cases, all these means can be divided into five categories:

1. *Electronic components* (21/45): micro-controllers, battery packs, rotating motors, vibrating motors, LEDs, paper electronics, paper circuits, programmable projections, circuits, copper tape, conductive thread and fabric, coin cell batteries, sensors and actuators, Arduino board;
2. *Crafting materials* (18/45): cardboard, wood, paper, paint, scissors, tape, glue, pipe cleaners, fabric, colored pencils, recycled materials, Play-Doh, graphite, aluminium, beads, sequins, acrylic;
3. *Devices* (15/45): computers, 3D printer, laser cutter, 3D scanner, headphones, and speakers;
4. *Toolkits* (14/45): Arduino, Lilypad Arduino, Makey Makey, CircuitScribe, PicoBoard, Lego WeDo and little Bits, TALKOO kit, fundakit, Dolly 2.0, Spark!, ID toolbox, Lego RCX, Crickets;
5. *Software* (10/45): Scratch, Meshmixer, Thingiverse platform, Tinkercad, graphics design software.

Cloud technologies allow organizing robotics training distantly. Tinkercad program attracts special attention. Tinkercad is a free, online 3D modelling program. It has been running since 2011. Tinkercad has been known as a 3D object development program. However, there is a tool Circuits, it allows to develop electronic circuits (figure 1). This ability appeared only in 2017, so this feature is quite new for teachers. Since then, the program has gained popularity among teachers of robotics.

Tinkercad has advanced capabilities for use in lessons. It has a number of significant advantages, described below.

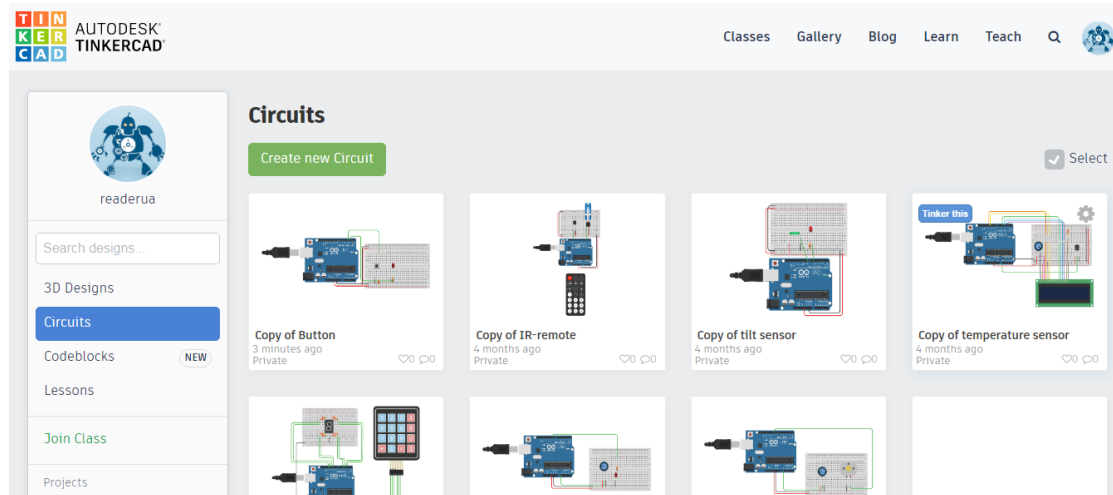


Figure 1: Interface of Tinkercad editor.

1. Tinkercad supports authorization at the level of separation of teacher and student rights. Teacher's account gives access to a special menu item. The teacher has access to students' accounts. He can moderate and comment. It makes the ability to enable a Safe Mode for any of their moderated students. This mode prevents students from viewing or creating comments on Tinkercad designs, and limits their gallery view to a curated list of designs approved by teachers. Classes in Tinkercad allow placing examples of electronic circuits and exchanging data on the course pages.
2. The Class Gallery allows seeing all student projects at once. In addition, students can see each other's projects and participate in their discussion.
3. Ability to share projects with friends. Public project can be integrated into another project by following the link. Such integration is an important element of the usability interface. The public project is available to all participants in the class, but remains private to external users. It is also possible to join the class by following the link, without authorization in Tinkercad system. It can be used in teachers' seminars or other irregular meetings.
4. A significant advantage is the teacher's ability to create separate classes and the function of integration with Google Classroom. Public Tinkercad designs can now be shared or assigned as homework using the popular Google Classroom platform.
5. It contains the library of ready-to-use lesson plans. These lesson plans contain a complete description of the project and allow the teacher to use them for distance learning. Each project contains step-by-step instructions.
6. It contains a sufficiently complete basic set of electronic devices, sensors and motors for modelling electronic circuits based on the Arduino microcontroller.
7. It supports modes: modelling, programming, reproduction of work of devices, the monitor of output of the information and the monitor of diagram's construction, a mode of making up of electronic circuit set (figure 2).

8. It contains grouping of projects in different folders. This approach allows making a distinction between didactic materials for different topics and subjects.
9. It has sharing editing of electrical circuits. Providing shared access to the project makes conditions for organizing teamwork of students. It is also possible for the teacher to view and edit student's data.

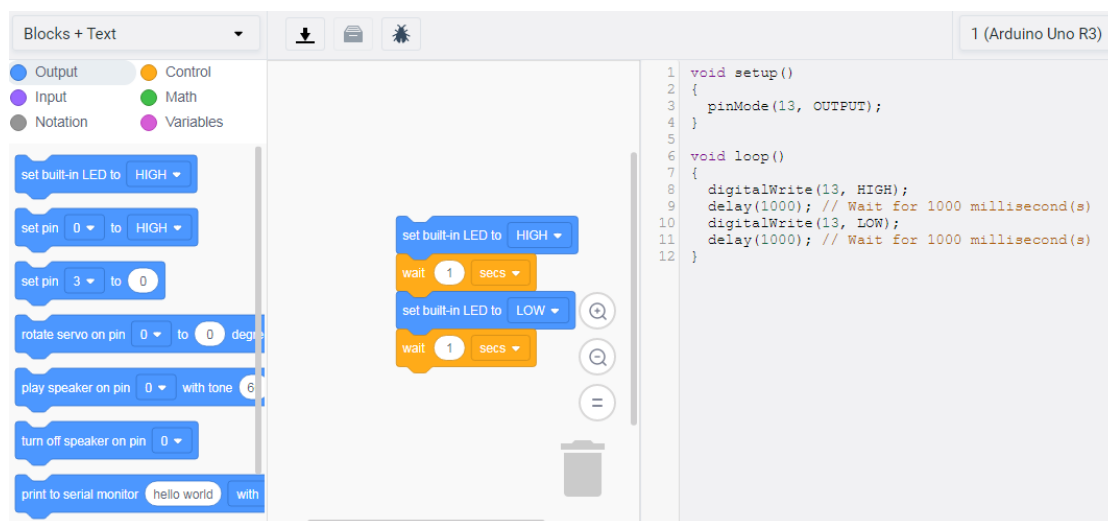


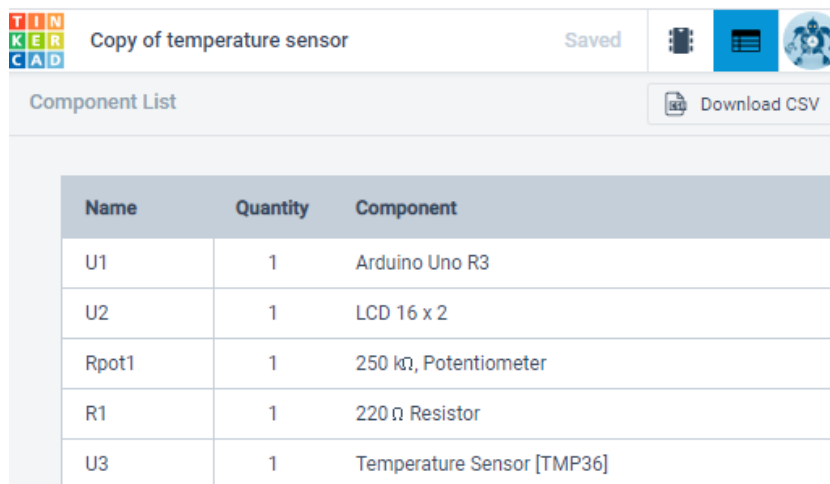
Figure 2: Example of Tinkercad programming environment.

This functionality makes the conditions for the use of the cloud environment as a platform for various activities. The ability to share projects allows exchange of experiences in extracurricular activities, such as a competition or festival. You can organize the development of different types of projects: applied projects (explanation of physical phenomena, solving problems in electronics, computer science), research projects (solving environmental problems or smart city technologies developing), information projects (studying the characteristics of electronic devices and components)

The particular interest to teachers is the ability to design software for robotic systems in the Tinkercad system. Tinkercad supports C++ programming language for Arduino. It is also possible to develop software in the visual programming editor Codeblocks (figure 2). This feature allows conducting classes for younger students. Visual programming commands, like Scratch, support Drag and Drop technology; it simplifies the process of program developing.

Building robotic projects in Tinkercad system helps to make real robotic devices [37]. The mode of the electronic circuit set of devices (figure 3) automatically develops the list of components that were used in the constructed circuit. It helps quickly to estimate the number of items and their cost. It is possible to export the table in CSV spreadsheet format. It is important for making of prototyping devices for subsequent acquisition of circuit elements.

A significant advantage of Tinkercad is the ability to demonstrate the operation of the electronic circuit. There is a special mode Smart Simulation, in which the electronic circuit begins to “work” (figure 4). In this mode, it can be verified the device connections are correct and



The screenshot shows the Tinkercad interface with a project titled "Copy of temperature sensor". The component list table is as follows:

Name	Quantity	Component
U1	1	Arduino Uno R3
U2	1	LCD 16 x 2
Rpot1	1	250 k Ω , Potentiometer
R1	1	220 Ω Resistor
U3	1	Temperature Sensor [TMP36]

Figure 3: Display of a set of electronic circuit devices.

the application is working properly. Smart Simulation is important for developing programming skills. There is experiment with code changes by changing the program code.

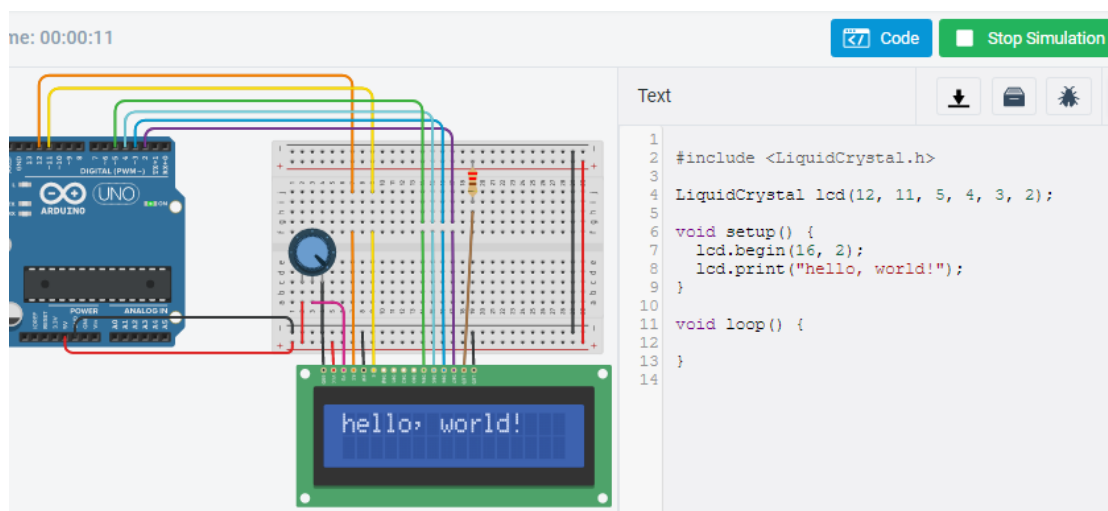


Figure 4: Example of basic project in Tinkercad.

We have developed a course of distance learning in robotics for students. The content of the course is a set of tasks with a practical component. Each of the tasks has a clear practical significance. In class, students developed the projects of things that exist in the real world. For example, they designed a prototype of alarm system, code lock safe, garland, meteorological centre, distance control of the robot.

The catalogue of elementary connection diagrams of robotic devices and sensors was created (figure 4). Execution of a series of basic tasks allows intensifying cognitive activity on

related topics: physical properties and laws, structures and programming algorithms, structural engineering, etc.

So, in the process of using the Tinkercad cloud environment, you can create prototypes of electronic devices, test hypotheses about the structure and connection of project components, options for device control programs. But in the process of creating the course materials, we made sure to highlight projects consisting of devices that are in the Tinkercad library.

The use of Tinkercad is due to several reasons: first, the lack of access to robotic construction sets, due to poor material support or a pandemic; secondly, the possibility of creating a model and testing it for further acquisition of the necessary components in independent research activities

Among the disadvantages of Tinkercad are the simulated physical parameters of the electronics in the program work perfectly, without “noise” and external influences. It does not accurately convey the process of setting up a real electronic element. The following types of errors or malfunctions in students’ work are possible during the work of an electronic device development:

- at the stage of physical model of device developing – incorrect connection of elements, lack of contact in the circuit, broken wire, malfunction of batteries or electronic components, etc.
- at the programming stage – no element initialization, incorrect program code.

The process of assembling and connecting the electronic circuit requires control over the contacts and closure of the electrical circuit. The simulation environment also eliminates elements of accidental device failure. Such faults must be checked by a special tester. Such errors often occur in students at real electronic circuits making.

Thus, the use of Tinkercad in robotics classes engages students in active activities and stimulates additional motivation to develop projects. At the expense of modeling of the project in a cloud carrying out of experimental and research work is provided. The project testing mode will provide savings in the purchase of electronic components.

Therefore, in the Tinkercad cloud environment, prototypes of electronic devices, test hypotheses about the structure and connection of project components, variants of device management programs can be developed. But in the course materials creating, we need to single out projects that consist of devices that are in the Tinkercad library.

The use of Tinkercad is due to several reasons: first, the lack of access to robotic designers, due to poor logistics or a pandemic; secondly, the ability to create a model and test it, to further acquire the necessary components for independent research. The teacher has the opportunity to: organize teamwork in the project, integrate tasks into Google Classroom, create a gallery of works and organize a discussion or competition of ideas and their implementation. Repositories for both teacher and students and access within the group are created. The teacher’s work should take into account: formulation of the project task, organization of discussion of ways to solve the problem, highlighting the consequences of the project (both positive and negative), checking the results of the project, forming a response.

4. Conclusions and future work

The preparation and implementation of the project in robotics contributes to the formation of a scientific approach to solving problems, technological literacy, skills in the use of modern digital technologies, integration of scientific concepts and understanding of interdisciplinary links. Due to the inaccessibility of robotic designers for the quarantine period, Tinkercad cloud environment was selected for the work and a number of projects were developed. They simulated various robotic systems in a virtual environment.

The purpose of construction of the course material is to form conceptual connections between theory and practice, to plan the study of fundamental disciplines, to create the interaction between the participants of the educational process. In the course of project activities, students formed a holistic view of the problem as a scientific complex task that requires the knowledge integration from different fields and has a practically significant component. They allow developing an integrated approach to learning based on a combination of different courses in science and mathematics.

Further research on the use of cloud technology in robotics classes is related to the use of control environments for robotic systems through cloud resources.

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