

Selection of online tools for creating math tests

Oksana V. Zaika¹, Tetiana A. Vakaliuk^{2,3,4}, Andrii V. Riabko¹, Roman P. Kukharchuk¹, Iryna S. Mintii^{3,4} and Serhiy O. Semerikov^{3,4,5,6}

¹Olexander Dovzhenko Glukhiv National Pedagogical University, 24 Kyievo-Moskovska Str., Glukhiv, 41400, Ukraine

²Zhytomyr Polytechnic State University, 103 Chudrivska Str., Zhytomyr, 10005, Ukraine

³Kryvyi Rih State Pedagogical University, 54 Gagarin Ave., Kryvyi Rih, 50086, Ukraine

⁴Institute of Information Technologies and Learning Tools of the NAES of Ukraine, 9 M. Berlynskoho Str., Kyiv, 04060, Ukraine

⁵Kryvyi Rih National University, 27 Vitalii Matusevych Str., Kryvyi Rih, 50027, Ukraine

⁶University of Educational Management, 52-A Sichovykh Striltsiv Str., Kyiv, 04053, Ukraine

Abstract

The article considers online tools for creating tests, which should be used when teaching mathematics in both higher education and general secondary education. Among the variety of online means of creating tests by the method of expert evaluation, three were identified, which allow conducting various tests both in the classroom and remotely, which are free and do not require special conditions for their use and which work on smartphones. The advantages and disadvantages of three online tools for creating tests Kahoot!, Quizizz, Classtime are analyzed, and a comparative description of the selected tools is given. Criteria for the selection of such tools were identified – functional-didactic and organizational. The following indicators belong to the functional-didactic: the presence of different types of questions, including open-ended; use of formulas, both in questions and in answers; use of pictures, both in questions and in answers; no restrictions on the length of questions and answers; instant receipt of results by the teacher, their evaluation and analysis; instant receipt of results by the respondent; to the organizational: the availability of a free version; no need to install the program; ease of use – characterizes the convenience and clarity of the interface for creating tests and their use; possibility of testing in online and offline mode; time limits, both for a single question and the whole test; random order of questions/answer options; instant demonstration of the correct answer to the respondent. With the help of expert evaluation, it was found that according to these criteria, Quizizz is the most appropriate for testing.

Keywords

online tools, Kahoot!, Quizizz, Classtime

AREdu 2021: 4th International Workshop on Augmented Reality in Education, May 11, 2021, Kryvyi Rih, Ukraine

✉ ksuwazaika@gmail.com (O. V. Zaika); tetianavakaliuk@gmail.com (T. A. Vakaliuk); ryabko@meta.ua

(A. V. Riabko); kyxap4yk1@ukr.net (R. P. Kukharchuk); irina.mintiy@kdpu.edu.ua (I. S. Mintii);

semerikov@gmail.com (S. O. Semerikov)

🌐 <http://pfm.gnpu.edu.ua/index.php/struktura1/2015-04-01-14-50-26> (O. V. Zaika);

<https://sites.google.com/view/neota> (T. A. Vakaliuk);

<http://pfm.gnpu.edu.ua/index.php/struktura1/2015-04-01-14-50-26> (A. V. Riabko);

<http://pfm.gnpu.edu.ua/index.php/struktura1/2015-04-01-14-50-26> (R. P. Kukharchuk);

<https://kdpu.edu.ua/personal/ismintii.html> (I. S. Mintii); <https://kdpu.edu.ua/semerikov> (S. O. Semerikov)

🆔 0000-0002-8479-9408 (O. V. Zaika); 0000-0001-6825-4697 (T. A. Vakaliuk); 0000-0001-7728-6498 (A. V. Riabko);

0000-0002-7588-7406 (R. P. Kukharchuk); 0000-0003-3586-4311 (I. S. Mintii); 0000-0003-0789-0272 (S. O. Semerikov)



© 2021 Copyright for this paper by its authors.
Use permitted under Creative Commons License Attribution 4.0 International (CC BY 4.0).

CEUR Workshop Proceedings (CEUR-WS.org)

1. Introduction

1.1. The problem statement

The COVID-19 pandemic has made an irreversible change in the normal existence of all people [1, 2, 3, 4, 5, 6], but it has changed the lives of those involved in the education system the most – both teachers and students [7, 8, 9]. The organization of distance learning (DL) in the spring of 2020 showed the existence of a range of problems in the mechanism of providing education by distance, in particular – the choice of DL technologies, time distribution between synchronous/asynchronous mode, accounting for working time and wages [10, 11, 12]. The solution to these problems is proposed in the Regulation on the distance form of complete general secondary education [13], adopted in the autumn of the same year. Thus, it states that to ensure uniform approaches to the creation of an electronic educational environment in the educational institution, the pedagogical council approves the use of specific information and telecommunication systems (electronic educational platforms), online communication services, and tools used to organize the educational process during DL. Within the framework of such unified approaches, pedagogical workers, using academic freedom, can choose forms, methods, and means of DL [13]. However, to make a considered and balanced choice of “specific information and telecommunication systems (electronic educational platforms), online communication services and tools” it is necessary to know their advantages, disadvantages, opportunities. Therefore, during quarantine, teachers are forced to “not only teach, but also to master new technologies” [14].

An integral part of the learning process (and not only distance) is the control and assessment, which can be carried out “in the process of daily study of students’ learning outcomes in class and at home, as well as the results of testing student achievement: oral, including individual, group and face-to-face interviews; written, in particular, independent and control works, testing” [15].

In [13] it is determined that “assessment of students’ learning outcomes can be carried out in person or remotely using the capabilities of information and communication (digital) technologies, including video conferencing”.

However, all the same, quarantine restrictions require online assessment. The use of online services for testing provides an opportunity to monitor and evaluate student achievement in various forms, set up automatic assessment and analysis of answers, instantly provide the student with test results, etc.

Currently, teachers have access to some such services – it’s Google service, Classtime, Online Test Pad, Eazy Test Maker, Kahoot!, Quizizz etc. By what criteria do you compare these online tools? What can be neglected, and what should be paid special attention to is the question of the study.

1.2. Analysis of recent research and publications

The issue of DL was particularly acute during the COVID-19 pandemic, but scientists around the world have been working on it for years. Teaching mathematics using DL technologies has long been studied by a team of scientists from Donbass State Engineering Academy, Donbass National Academy of Civil Engineering and Architecture, The Institute of Chemical Technologies (the

town of Rubizhne) of the East Ukrainian Volodymyr Dahl National University and Kryvyi Rih State Pedagogical University chaired by Kateryna V. Vlasenko, who are developers of the open platform of online education “Higher School Mathematics Teacher”. The purpose of this platform is “how to teach a student, who gets engineering education, to study mathematics”. *Differential Equations* and *Operations Research* oriented to cloud computing in the CoCalc system are currently available on the platform. Vlasenko et al. [16] highlight as a process of using this platform for online training of master students, majoring in Mathematics for internship in technical universities, issues that may arise in students during the internship, discuss the need to consider needs of students during the development of courses, and certain features of the platform, in particular, justify its minimalist interface [17] and explore the criteria of usability [18]: information quality, system navigation, system learnability, visual design, instructional assessment, and system interactivity and responsiveness.

Representatives of the Myroslav I. Zhaldak’s scientific school also highlight the experience of using DL technologies for teaching mathematics on the example of the use of cloud technology in mathematical calculations, use of Gran1, Gran2D, Gran3D software [19]: “In particular, the calculation of the approximate value of the double integral; graphical two-dimensional problem solving, the so-called linear programming problems; two-dimensional problems, including convex programming – finding the smallest value of a convex downward function (or the highest convexity of a function) on a convex set of inequalities (including linear ones)”.

Kramarenko et al. [20] improve the study of mathematics by using cloud technologies and dynamic mathematics system GeoGebra in the educational process through Stereometry specialized training.

Kramarenko et al. [21] investigate the problem of studying mathematics using ICT in the inclusive class; Lovianova et al. [22] – the problem of introducing cloud calculations into 10th-11th graders’ training to solve optimization problems in the context of the STEM education concept; Shyshkina and Marienko [23] 0- the task of improving the math teachers’ ICT competence using cloud services use in the training process.

Bobyliiev and Vihrova [24] demonstrate the method of DL of mathematics using LMS Moodle on the example of the courses “Mathematical Analysis” and “History of Mathematics”.

It is worth noting that LMS Moodle is one of the most popular platforms to support DL not only in Ukraine but also around the world. However, studies by different authors focus on different aspects of its use. For example, The and Usagawa [25] developed a pilot e-learning program based on online quizzes. The obtained results testified to the higher marks on the final test of students after self-study and practice using online quizzes. Smoline [26] discusses some inconsistencies in testing that are characteristic of some LMS, in particular, Moodle and Blackboard. However, a special test description language is offered, designed specifically for math tests. Gangur [27] also investigates the activities of students within a particular LMS in terms of mathematical problems. They mainly offer to organize educational activities using tests with automatically-generated questions. They also demonstrate the solution of certain problems related to the creation of mathematical problems with parameters.

About online testing and testing in general by e-learning, this issue is similarly considered by scientists for more than a year in various fields. Thus, Rakov et al. [28] investigated data processing technologies for calculating the prognostic validity of tests of academic achievement, Tarasenko et al. [29] proposed an integrated system for testing the components of information

competence of future translators. Also, Shapovalova et al. [30] proposed an adaptive testing model as a method of individualization of knowledge quality control, and Mrela and Sokolov [31] proposed to put students' ratings on based on the assessment by experts of the levels of verification of learning outcomes on test tasks.

Some authors have explored the possibilities of LMS in test control of knowledge, in particular, Abdula et al. [32] investigated the features of the use of Moodle test tools in teaching philosophy, and Mintii et al. [33] considered the possibility of importing test questions into LMS Moodle.

Regarding the teaching of mathematics, Lvov and Shmarova [34] studied the generation of test problems in computer mathematics systems for educational purposes.

Some online testing tools are discussed in [35, 36, 37, 38, 39, 40, 41, 42].

Thus, Jiemsak and Jiemsak [35] identified the capabilities of the Quizizz service as a tool for evaluation and self-evaluation. According to the results of the experiment, students were positive about self-esteem using Quizizz.

Chaiyo and Nokham [36] showed the results of the impact of using Kahoot, Quizizz, and Google Forms services on concentration, involvement in the process, results, motivation, and satisfaction. The obtained results testified to the presence of significant differences.

Anderson [37] explores the possibility of using Google Forms for online surveys designed to gather feedback on the daily coverage of students with the content of training and the distribution of classroom time. These surveys help to get feedback on uncompleted tasks. The experiment was conducted in a variety of mathematical courses – from calculus to abstract algebra, which influenced the success, participation, and reach of students.

Popescu and Avram [38] consider Google Forms as a tool for monitoring the complex activities of project participants at different stages of compliance with the planned results. The authors note that Google Forms is a simple tool that has an intuitive interface, allows you to get instant results and user feedback.

McConnel [39] also suggests using Google Forms to increase student engagement. But they purposefully use open daily thinking to allow students to take responsibility for their learning (not the question “Why did you learn during this week”, but for example, “Is there something you want me to know?”). This gives students the opportunity to talk more openly about group work, social issues and topics of interest to them, and the data collected is useful for teachers to build more trusting relationships.

Some works are devoted to the use of Kahoot! in the educational process and service. Thus, Aras and Çiftçi [40] conducted a study to compare the impact on the consolidation of traditional survey material and using the Kahoot! service, but no statistical differences were found. In the work of Pereira de Sousa [41] the results obtained indicate that the use of the service Kahoot! for the joint development and use of quizzes and tests provided an opportunity to gamify learning and led to greater involvement of students in the course, and, as a consequence, contributed to a more conscious work on the course.

Domínguez et al. [42] also focuses on the capabilities of Kahoot! and Classtime services to gamify learning and thus turn a regular teacher survey into a competition.

Other authors are trying to integrate some of the existing services. Thus, Wildgoose and Bakrania [43] have developed a new evaluation tool that combines the capabilities of Google Forms and the versatility of complex task development with multiple choice in Google Sheets. Using this tool allows teachers to create a library of questions, edit numerical parameters that

update the formulated answers (which is essential for mathematical disciplines), select questions, and perform the instant evaluation. The results of the experiment showed greater involvement of students.

When researching the characteristics of online tools, it is worth paying attention to the results of Nielsen [44], who was one of the first to use the term “usability” – the ease of use of the software. In particular, Nielsen [44] identifies the following criteria: “the user can determine the state of the system; the system uses user-friendly terminology; free control of the system, support for the function of deletion (undo) and repetition function (redo); consistency and standards; prevention of errors and warning the user about further problems; minimization of the load on the user’s memory; flexibility and efficiency of use; aesthetic and minimal design; the system should offer the user a constructive solution to emerging issues; availability of reference information in the system”.

Thus, we see that scientists are working fruitfully to study the use of DL technologies for teaching mathematics, explore the possibilities of individual tools, but need a comprehensive study of the most popular online testing services with an emphasis on the peculiarities of their use for mathematical problems.

Therefore, the *purpose* of the article is a method of expert selection to select according to certain criteria and indicators of online means of creating tests for use in the professional activities of mathematics teachers.

2. Methods

To identify an appropriate online tool for creating tests for teaching mathematics to both students of higher education institutions and students of general secondary education, the method of expert assessment was used [45]. The experts were interviewed in two stages.

Consider them. The first stage of the survey of experts. Specialists were asked to evaluate 6 test programs that can be used to teach mathematics in educational institutions, and which are adapted for smartphones. Teachers and teachers of mathematics (12 people in total) were involved for expert evaluation. The study was conducted based on Olexander Dovzhenko Glukhiv National Pedagogical University.

As part of our study, they used the scoring system proposed in [45], according to which for the number of 6 tools - the maximum score of 6 will receive the most important test platform in use, and the lowest score of 1 will receive the least significant. To establish the existence of an objective agreement between experts, the Kendall’s coefficient of concordance is determined [45].

After performing the necessary calculations using experimental data, we obtain a certain value of the Kendall’s W . In the case of a significant difference from zero, the calculation results determine the existence of an objective agreement between experts ($W = 0$ – no link between ranking experts, $W = 1$ – ranking completely coincide), the total ranks are quite objective.

In the second stage of the study, a group of experts was involved to determine the most significant test platforms according to certain criteria. The manifestation of each of the given criteria was evaluated for each of these means of testing students on the appropriate scale [45].

The indicator is considered positive if the value of the arithmetic mean of all indicators of

this criterion is not less than 1.5 [46]. The criterion is:

- insufficiently manifested, if more than 50% of its indicators are negative;
- critically manifested, if 50% – 55% of its indicators are positive;
- sufficiently pronounced if 56% – 75% of its indicators are positive;
- and highly manifested, if 76% – 100% of its indicators are positive

3. Results

To identify an appropriate online tool for creating tests while teaching mathematics, (including future teachers of mathematics), we will use the method of expert assessment, which is described in detail above. To compile a list of proposed online test-taking tools, a survey of teachers and educators directly involved in teaching mathematics in the institutions of higher education and the general secondary education institutions was conducted to determine which online test-taking tools are preferred in different educational institutions.

As a result, the following list of Classtime, Google Forms, Online Test Pad, Eazy Test Maker, Kahoot, Quizizz was formed.

However, it should be noted that not all of these services have the characteristics that should be in the means of mathematical orientation. Thus, one of the important characteristics is the ability to use formulas (both in questions and answers), the use of figures (again, both in questions and answers), changes in parameters in formulas, etc.

At the first stage, the experts were asked to take a survey to rank the selected test programs on a scale from 1 (minimum score) to 6 (maximum score). The survey results are presented in the table 1.

Table 1
Ranking of online tools for creating tests in teaching mathematics

Number of expert	Tools					
	Classtime	Google Forms	Online Test Pad	Eazy Test Maker	Kahoot	Quizizz
1	5	3	1	4	2	6
2	6	3	1	2	4	5
3	4	3	2	1	6	5
4	6	2	1	4	3	5
5	3	4	1	2	5	6
6	6	3	2	1	5	4
7	4	3	2	1	6	5
8	3	5	6	1	2	4
9	4	3	1	2	6	5
10	5	2	6	1	3	4
11	3	5	6	1	2	4
12	5	3	1	2	4	6
S	54	39	30	22	48	59
d	12	-3	-12	-20	6	17

After performing the calculations according to the appropriate formulas, we have $W = 0.41$, i.e. the Kendall's coefficient of concordance is different from zero, and therefore there is an objective agreement between the experts. As a result, three test platforms Classtime, Kahoot, Quizizz were selected. Consider their advantages and disadvantages of their use in the educational process to control the educational achievements of students.

Kahoot!. There are different Kahoot! tariff plans [47]. The simplest in terms of equipment and free is the basic tariff plan, which includes:

- involvement of students (in the classroom and through video; tasks with students);
- creation of the test (ready tests, bank of questions, to create own collections of questions);
- types of questions (test with answer options (one of four), yes / no);
- assessment (training with video conferences, reports for the formation of assessment);
- settings (login generator, music options);
- cooperation (1 group of teachers).

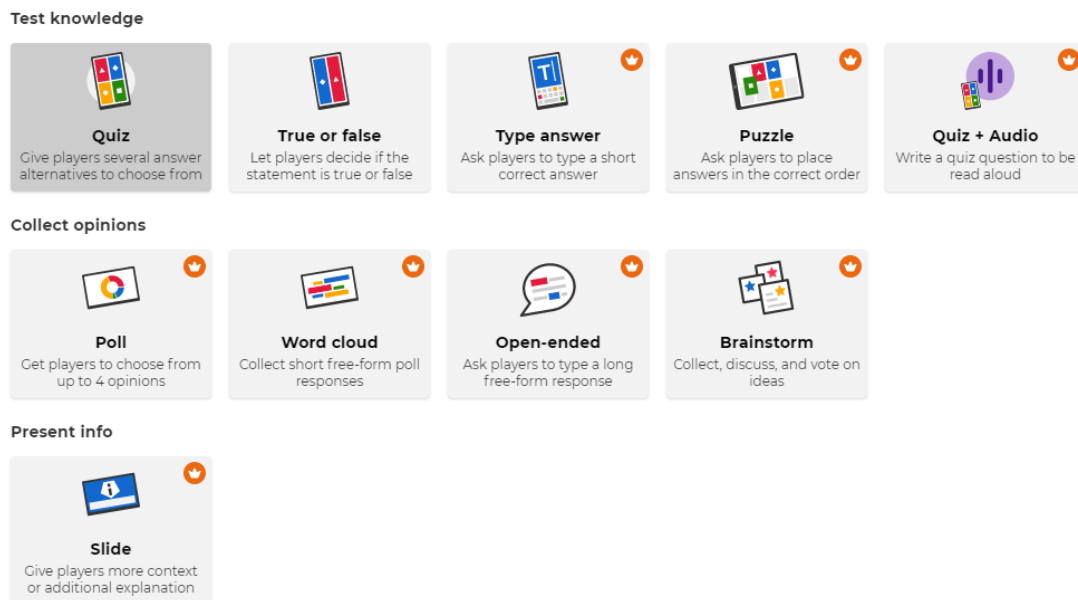


Figure 1: Types of tests in Kahoot!.

Consider the main features of this tool:

- There are several options for work: testing can take place online (virtual classroom), and you can take the test without contacting the teacher (self-study). Here the teacher sets the date and time limit during which the test will be open.
- There are different tariff plans: free and premium, for a certain price. But the free version is enough to quickly check the assimilation of certain material by students, both in

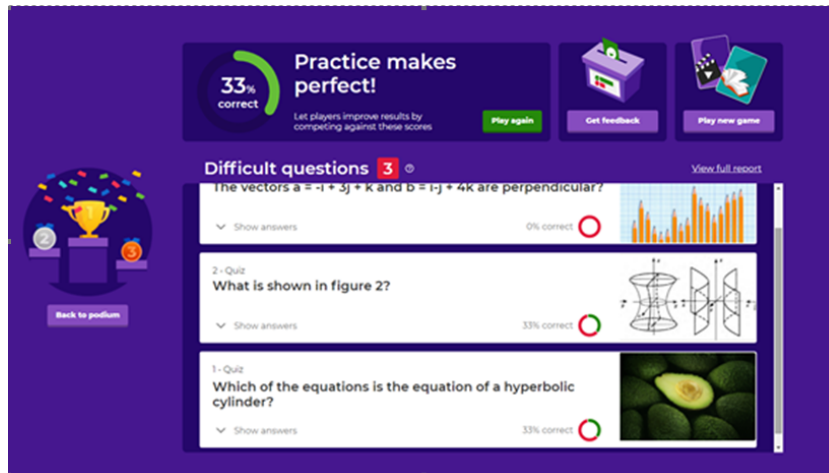


Figure 2: Test results.

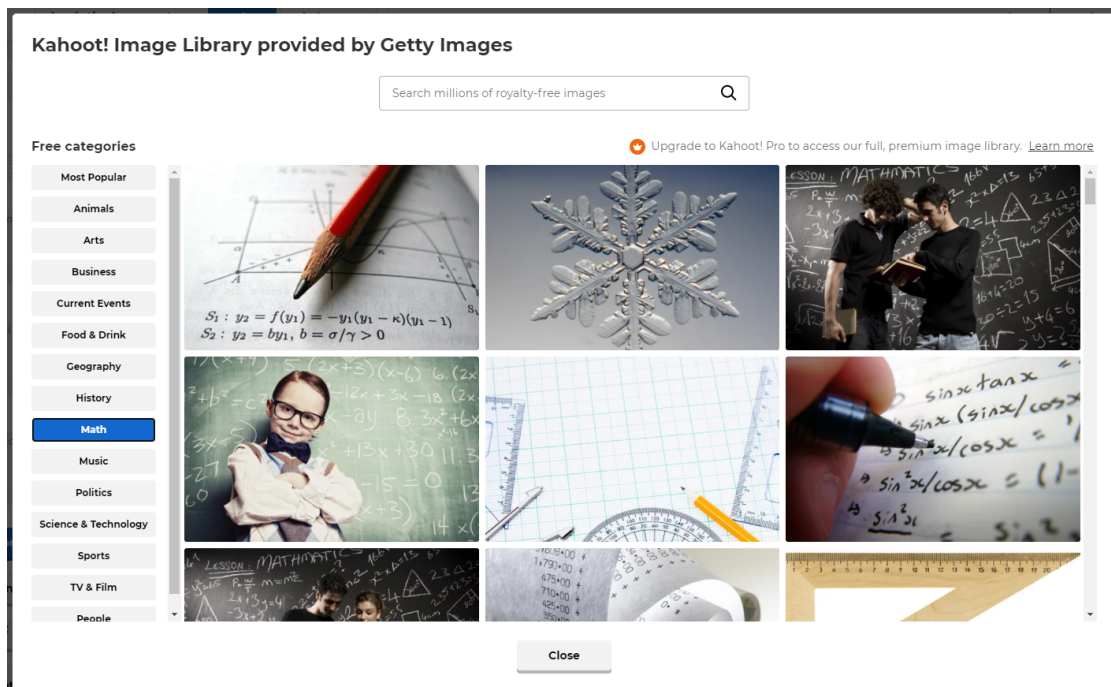


Figure 3: Categories of images.

preparation for the classroom – repetition of the necessary material, and in the final control.

- Premium class gives more opportunities in choosing the format of tests. In the premium class there is an opportunity to add your answer, both short and detailed; arrange the

answers in a certain order; add associations with a certain concept; express their opinions to create a dispute, etc. (figure 1).

- No need to download programs. All you have to do is go to Kahoot.it from your computer or smartphone, enter the PIN code of the test suggested by the teacher, and then – your name and start the game. During DL, it is necessary to connect participants to the video conference using any platform and display the question. When answering questions, each participant immediately sees where he is wrong. At the end of the test, the three best answers are displayed (up to 50 people can play at the same time in the free version), and the teacher has a report indicating the students with the number of points they scored and the most difficult questions (figure 2).
- You can set the time from 5 sec. to 240 sec. to think about the answer, the default is 20 sec. This makes it possible to set the pace of work during testing.
- It is possible to supplement the question with an image that can be meaningful – to supplement the question, to push the answer, or just a fun picture. Such images can be taken from your document, or you can use the ones already offered. There are different categories of images on different topics (figure 3).

Figure 4 shows what the field for creating a free quiz test looks like. You fill in questions, answers, set time limits, add images (figure 5).

- When the teacher chooses to “Play”, it is possible to establish the following points: a random order of questions and answers, which is very convenient for repeated testing, musical accompaniment, etc. (figure 6).

Figure 4: Question form template: initial.

What is shown in figure 2?

⊕
⊖
Skip

15

0
 Answers

▲ ellipsoid

◆ elliptical cylinder

● single-cavity hyperboloid

■ hyperbolic cylinder

Figure 5: Question form template: image – question.

Player vs Player
1:1 Devices

Classic

Team vs Team
Shared Devices

Team mode

Game options ▼

Enable Answer Streak Bonus View details	ON <input type="checkbox"/>
Name generator View details	ON <input type="checkbox"/>
Podium View details	ON <input type="checkbox"/>
Randomize order of questions	ON <input type="checkbox"/>
Randomize order of answers	ON <input type="checkbox"/>
Enable 2 Step Join View details	OFF <input type="checkbox"/>
Display Game PIN throughout	ON <input type="checkbox"/>

Figure 6: Game settings.

Using Kahoot! helps to correctly assess the knowledge of the student, being away from him. Tests can be used to update basic knowledge before a class, in particular, online, for a module test, final test, exam preparation, or test.

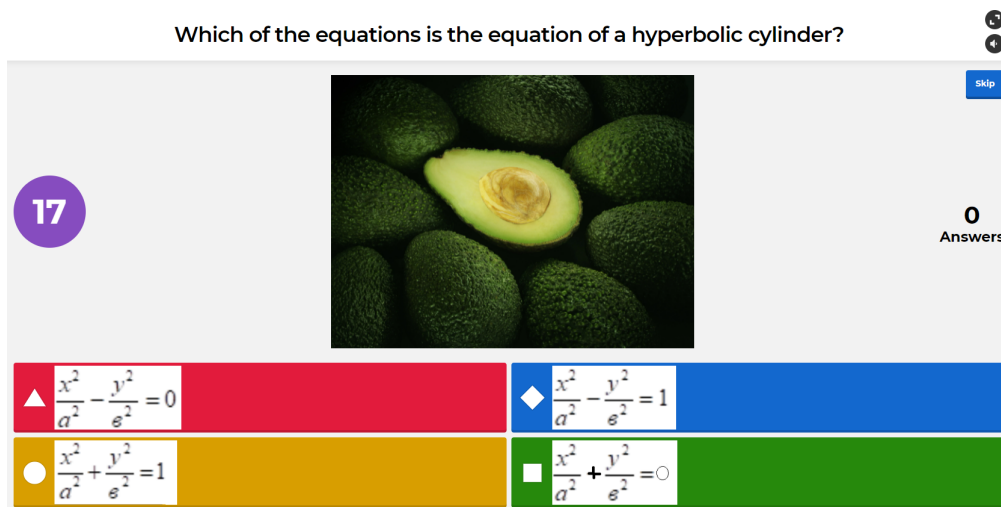


Figure 7: Answers-images.

The disadvantages of this program include:

- Lack of Ukrainian interface (there are English and Russian), automatic translation of Ukrainian text in the program in the finished test during the game.
- In the free version, only two types of tests are available: “Quiz” – the choice of one correct answer out of four, and the choice of “Yes / No”.
- Lack of formula editor. Although uppercase and lowercase modes are available in the answers. Formulas can also be inserted in the answer in the form of images (figure 7). In question, it is possible to recruit them using common notation.
- When creating a question, the teacher should think about the following: the question should be formulated, concisely, concisely. The answers should also be short (there is a limit on the number of words).
- During the online game, respondents do not see questions and answer options on their smartphones, they have only four cards; this is not always convenient, because you need to read the questions from the screen and not make a mistake (automatically) in choosing the picture.

Classtime. This online test creation tool is free, although it also offers a premium version that extends certain capabilities (for example, the ability to connect a group you already work within Google Classroom, set a time limit for the task) [48].

The advantages include:

- Availability of Ukrainian interface.

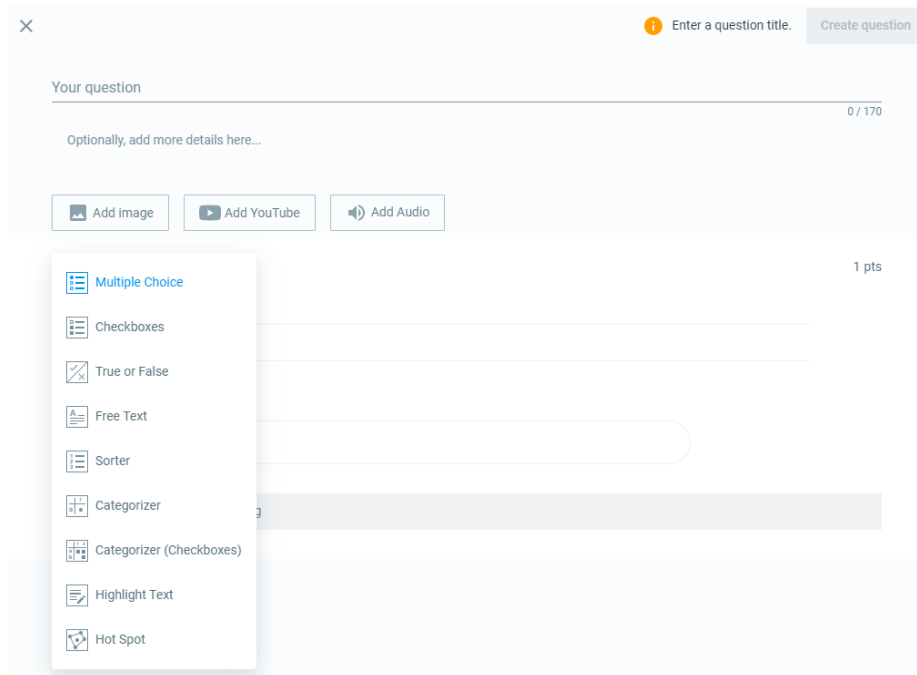


Figure 8: Types of tests in Classtime.

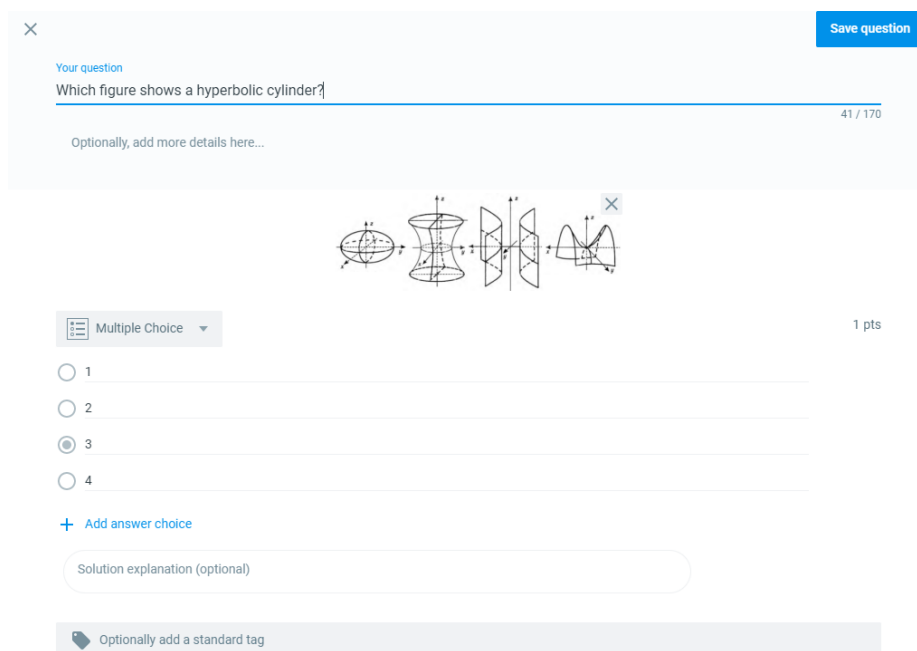


Figure 9: Adding an image in question; b) in response.

✕ Save question

Your question

What equation does the cone specify? 36 / 170

Optionally, add more details here...

Multiple Choice 1 pts

Answer choice 1

$\frac{x^2}{a^2} + \frac{y^2}{b^2} - \frac{z^2}{c^2} = 0$

Answer choice 2

$\frac{x^2}{a^2} - \frac{y^2}{b^2} - \frac{z^2}{c^2} = 0$

Answer choice 3

$\frac{x^2}{a^2} + \frac{y^2}{b^2} - \frac{z^2}{c^2} = 1$

[+ Add answer choice](#)

Solution explanation (optional)

Figure 10: Adding an image in response.

- The free version allows you to create tests of nine types: choosing one answer from the proposed, choosing several correct, matching, adding your answer, and others (figure 8).
- Ability to add images both in question and in response (images can be taken from your documents, as well as from the Internet) (figures 9, 10).
- When the teacher chooses to “Play”, it is possible to establish the following points: a random order of questions and answers, which is very convenient for repeated tests, the correct answer immediately or not, and more (figure 11).
- No need to download programs. The student comes by invitation and starts the game. Depending on the teacher’s actions, the participant either sees his mistakes immediately, or only the teacher announces his assessment.
- The teacher sees the table of answers, can conclude the complexity of the questions (what material was not mastered) and the number of points. If the type of question “own answer” was chosen, the teacher must assess the correctness of the answer (figure 12).

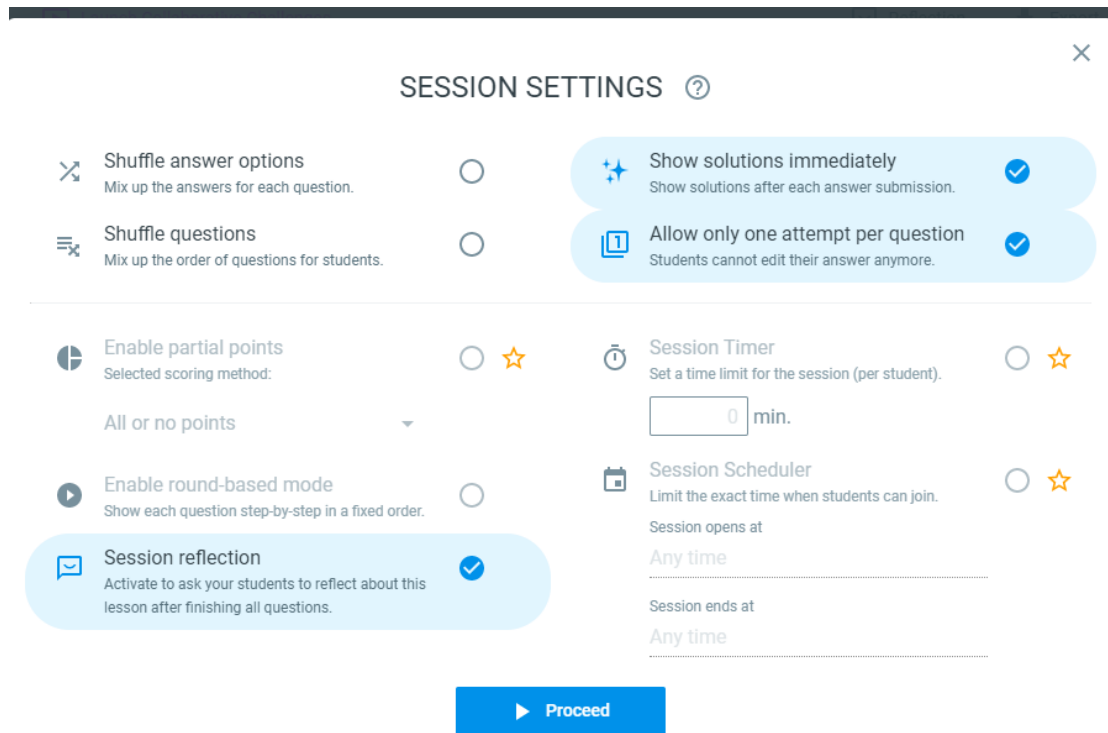


Figure 11: Game rules.

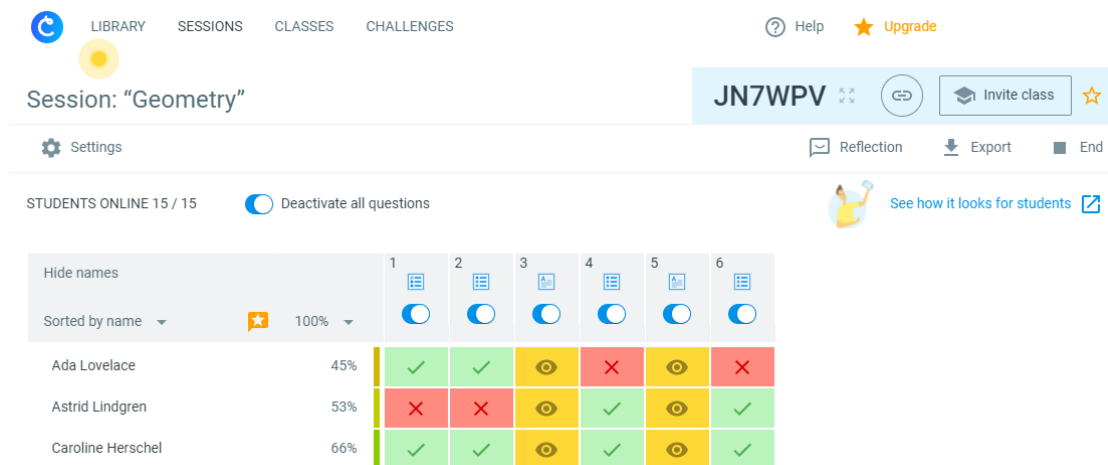


Figure 12: Test evaluation table.

The disadvantages include:

- Lack of formula editor. Formulas can be typed in the accepted format, i.e., for example, root – sqrt, and so on.
- The appearance of the test is a plain white sheet of paper with questions.
- It is not possible to set the time for the task in the free version (this option is present in the premium class).
- To start the game, the teacher must invite each participant by sending him an invitation and specifying the game code.
- The teacher does not control the pace of the task. It can only warn students that the test can be taken for a certain period and do not accept answers after the deadline.

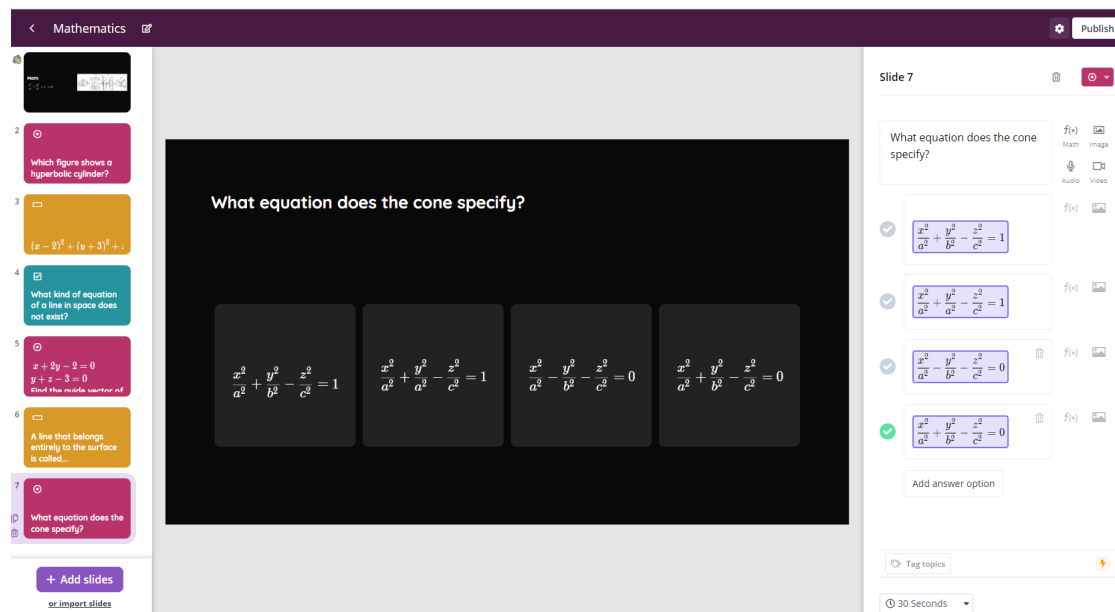


Figure 13: Formulas in tests.

Quizizz [49] is an online test creation tool. Here are the main features of this tool:

- No need to download programs. Just go to join.quizizz.com and enter the code suggested by the teacher.
- Available formula editor. Formulas can be typed both in the question and in the answers (figure 13).
- There are five types of tests available: choosing one answer, choosing several answers, adding your answer, questioning, reasoning. Also, you can choose ready-made questions from the Internet, if it suits you by topic (figure 14), or add slides.
- Ability to add images to both questions and answers. You can also add audio and video to the question.
- Bright interface of the question, which the test participant sees in his smartphone or computer (figure 15).

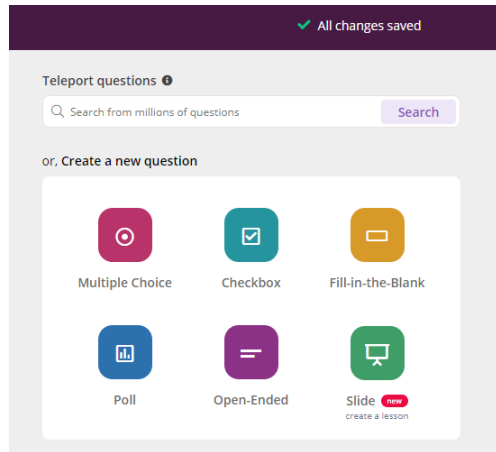


Figure 14: Types of tests.

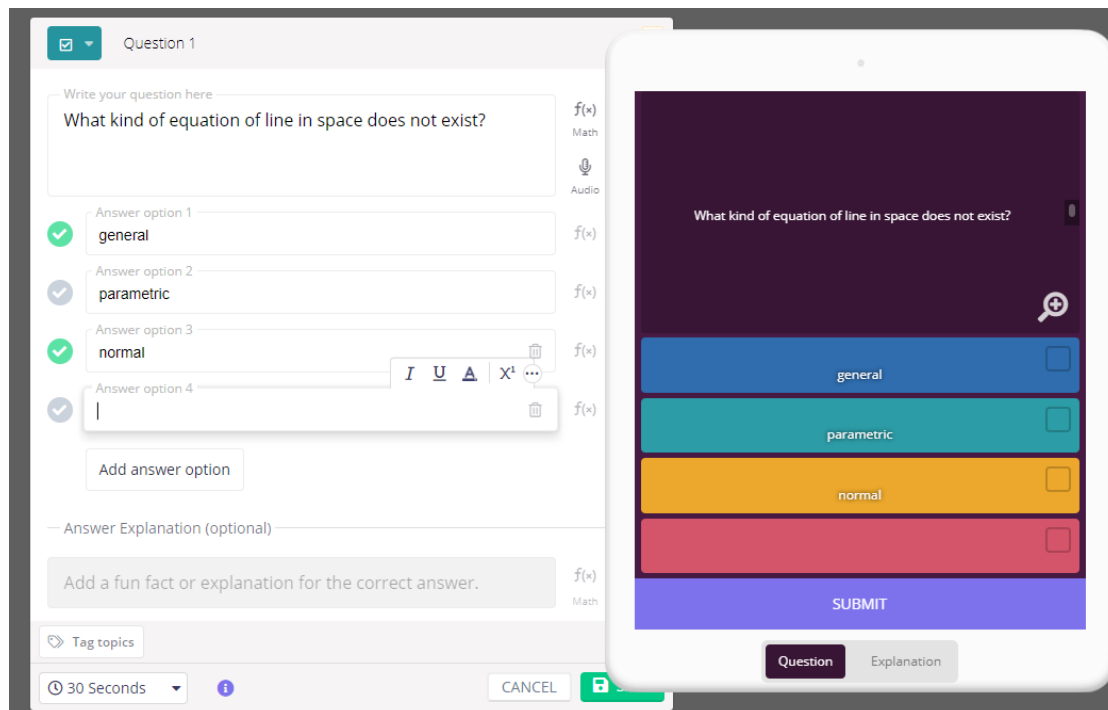


Figure 15: Interface questions.

- It is possible to set the pace of testing. Students can take the test at their own pace (during class or as homework), and the teacher can control the change of questions (online testing) so that participants can complete the test at the same time. Each question is set the maximum time allotted for its implementation (from 5 seconds to 15 minutes).

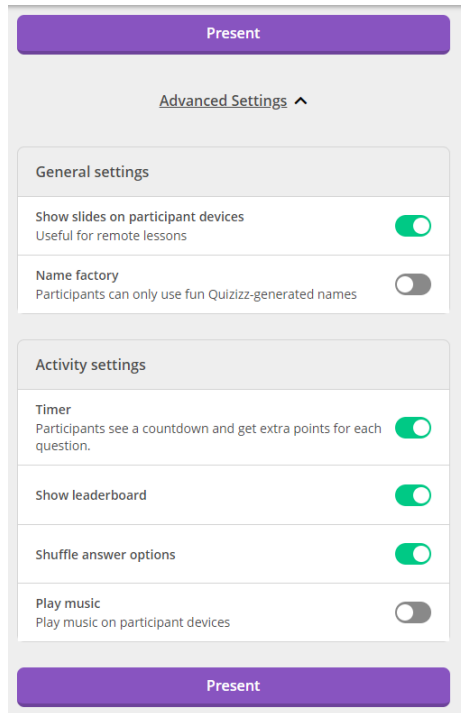


Figure 16: Game settings.

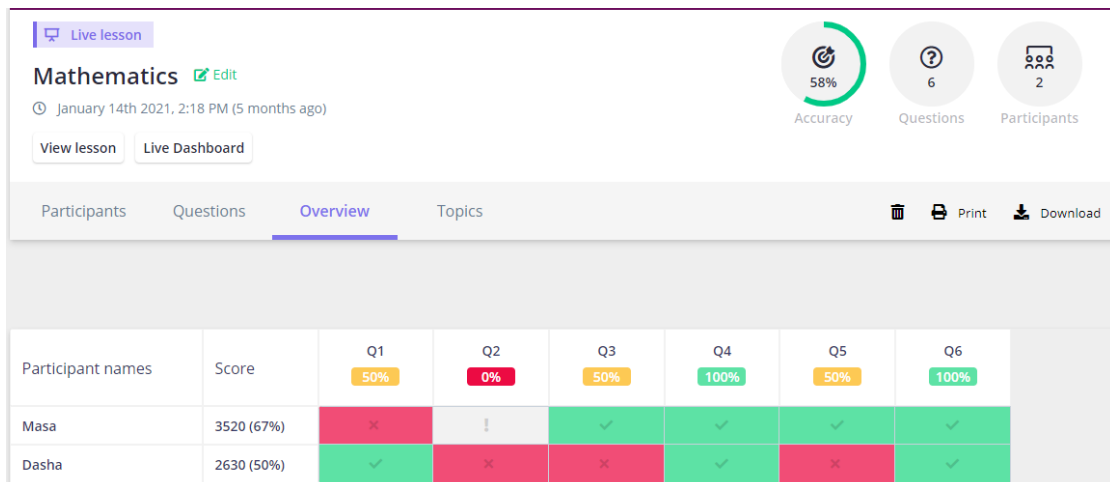


Figure 17: Test results.

- It is possible to customize the game (rearrange questions and answers, show the correct answer after the selection, show all the questions at the end of the game, etc.) (figure 16).
- On the teacher's screen you can immediately see the test results, the statistical table. The

results are presented in the form of a table, which can be used to assess which questions caused difficulties (have the largest number of incorrect answers, have a lot of time, etc.) (figure 17), it is possible to export the results to the Excel table; also, the teacher sees statistics on the completed homework (“My Reports”).

As for the shortcomings, this tool contains only the English and Russian interfaces, and the evaluation is influenced by the speed of the response (i.e. the phlegmatic already loses, even if he gives the correct answer).

The comparative analysis of the considered means gave the chance to form two criteria – functional-didactic and organizational, to each of which the group of properties on which further in research each of means will be estimated belongs. Thus, the first group (functional-didactic criterion) includes properties that characterize the functional and didactic component of the tool for testing:

- 1) the presence of different types of questions, including open-ended;
- 2) the use of formulas, both in questions and answers;
- 3) the use of pictures, both in questions and answers;
- 4) no restrictions on the length of questions and answers;
- 5) instant receipt of results by the teacher, their evaluation and analysis;
- 6) instant receipt of results by the respondent.

The results of the intermediate data of the expert survey on the functional-didactic criterion are given in the tables 2, 3 and 4.

Table 2

The results of assessment according to the functional-didactic criterion Kahoot!

№	The number of points for the indicator №					
	1	2	3	4	5	6
1	1	0	2	0	3	3
2	1	0	2	1	3	3
3	1	0	3	1	3	3
4	1	0	3	1	3	3
5	1	0	2	1	3	3
6	1	0	2	0	3	3
7	1	0	2	0	3	3
8	1	0	3	0	2	3
9	1	0	3	1	3	3
10	1	0	3	1	3	3
11	1	0	2	0	3	3
12	1	0	2	0	3	3
average	1	0	2.42	0.5	2.92	3

Let’s highlight the results of the indicators of functional and didactic criteria for each test tool (table 5).

The second group (organizational criterion) includes the properties that characterize the tool for testing from a technical point of view:

Table 3

The results of assessment according to the functional-didactic criterion Classtime

№	The number of points for the indicator №					
	1	2	3	4	5	6
1	3	1	3	2	3	2
2	3	0	3	3	3	2
3	3	0	3	3	3	2
4	3	1	3	3	3	2
5	3	0	3	2	3	1
6	3	1	3	2	3	1
7	3	1	3	3	3	2
8	3	0	3	3	3	2
9	3	1	3	3	3	1
10	3	0	3	2	3	2
11	3	1	3	2	3	1
12	3	1	2	2	3	2
average	3	0.58	2.92	2.5	3	1.6

Table 4

The results of assessment according to the functional-didactic criterion Quizizz

№	The number of points for the indicator №					
	1	2	3	4	5	6
1	3	3	3	2	3	3
2	3	3	3	3	3	2
3	3	3	3	3	3	3
4	3	3	3	3	3	2
5	3	3	3	2	3	3
6	3	3	3	2	3	3
7	3	3	3	3	3	3
8	3	3	3	3	3	2
9	3	3	3	3	3	3
10	3	3	3	2	3	2
11	3	3	3	2	3	3
12	3	3	3	3	3	3
average	3	3	3	2.58	3	2.66

- 1) the availability of a free version;
- 2) no need to install the program;
- 3) ease of use – characterizes the convenience and clarity of the interface for creating tests and their use;
- 4) the ability to test online and offline;
- 5) time limits, both for a single question and the whole test;
- 6) random order of questions/answer options;
- 7) instant demonstration of the correct answer to the respondent.

Table 5
Functional and didactic criterion and its selection indicators

Tools	The number of points for the indicator №						The manifestation of the criterion
	1	2	3	4	5	6	
Kahoot	1	0	2.42	0.5	2.92	3	50%
Classtime	3	0.58	2.92	2.5	3	1.6	83%
Quizizz	3	3	3	2.58	3	2.66	100%

The results of the intermediate data of the expert survey by organizational criteria are presented in the tables 6, 7 and 8.

Table 6
Results of the evaluation of the organizational criterion for Kahoot!

№	The number of points for the indicator №						
	1	2	3	4	5	6	7
1	3	3	2	3	3	3	3
2	3	3	1	2	3	3	3
3	3	3	1	2	3	3	3
4	3	3	1	3	3	3	3
5	3	3	2	3	3	3	3
6	3	3	2	3	3	2	3
7	3	3	2	2	3	3	3
8	3	3	2	2	3	3	3
9	3	3	2	2	3	3	3
10	3	3	2	3	3	3	3
11	3	3	1	2	3	3	3
12	3	3	2	3	3	3	3
average	3	3	1.7	2.5	3	2.92	3

Let us highlight the results of the organizational criterion for each test tool (table 9).

We present a final table of the results of the manifestation of all criteria for the selected test programs (table 10).

4. Conclusions

For the study, the method of expert evaluation was applied, which consisted of two stages: the first surveyed experts to select online tools for creating tests; the second identifies an online means of creating tests, which took place using certain selection criteria and indicators.

As a result, the following criteria and relevant indicators for the selection of such online test creation tools are identified:

- functional-didactic: the presence of different types of questions, including open-ended; use of formulas, both in questions and in answers; use of pictures, both in questions and in answers; no restrictions on the length of questions and answers; instant receipt

Table 7

Results of the evaluation of the organizational criterion for Classtime

№	The number of points for the indicator №						
	1	2	3	4	5	6	7
1	3	3	2	3	1	3	3
2	3	3	2	3	0	3	3
3	3	3	2	2	1	3	3
4	3	3	2	3	1	3	3
5	3	3	2	3	0	3	3
6	3	3	2	3	0	3	3
7	3	3	2	3	0	3	3
8	3	3	2	3	0	3	3
9	3	3	3	3	0	3	3
10	3	3	3	3	1	3	3
11	3	3	3	3	0	3	3
12	3	3	2	3	0	3	3
average	3	3	2.25	2.92	0.33	3	3

Table 8

Results of the evaluation of the organizational criterion for Quizizz

№	The number of points for the indicator №						
	1	2	3	4	5	6	7
1	3	3	3	3	3	3	3
2	3	3	3	3	3	3	3
3	3	3	3	3	3	3	3
4	3	3	3	3	3	3	3
5	3	3	3	3	3	3	3
6	3	3	3	3	3	3	3
7	3	3	2	3	3	3	3
8	3	3	3	3	3	3	3
9	3	3	3	3	3	3	3
10	3	3	3	3	3	3	3
11	3	3	3	3	3	3	3
12	3	3	3	3	3	3	3
average	3	3	2.92	3	3	3	3

of results by the teacher, their evaluation and analysis; instant receipt of results by the respondent;

- organizational: free version; no need to install the program; ease of use – characterizes the convenience and clarity of the interface for creating tests and their use; possibility of testing in online and offline mode; time limits, both for a single question and the whole test; random order of questions/answer options; instant demonstration of the correct answer to the respondent. As a result of the elaboration of the method of expert assessment, it was found that the most appropriate online means of creating tests when

Table 9
Organizational criterion and its indicators

Tools	The number of points for the indicator №							The manifestation of the criterion
	1	2	3	4	5	6	7	
Kahoot!	3	3	1.7	2.5	3	2.92	3	100%
Classtime	3	3	2.25	2.92	0.33	3	3	87.5%
Quizizz	3	3	2.92	3	3	3	3	100%

Table 10
Results of the manifestation of all criteria in selected test programs

Tools	Criterion	
	Functional-didactic	Organizational
Kahoot	50%	100%
Classtime	83%	87,5%
Quizizz	100%	100%

teaching mathematics is Quizizz.

A promising area of further research is to develop a methodology for using this online tool to create tests for testing in the study of mathematics, as well as to develop a system of tests for each lesson, where at any stage you can include a test to understand whether learners have mastered this the question of whether they are ready for class, etc.

References

- [1] M. Velykodna, Psychoanalysis during the COVID-19 pandemic: Several reflections on countertransference, *Psychodynamic Practice* 27 (2021) 10–28. doi:10.1080/14753634.2020.1863251.
- [2] S. Semerikov, H. Kucherova, V. Los, D. Ocheretin, Neural network analytics and forecasting the country's business climate in conditions of the coronavirus disease (COVID-19), *CEUR Workshop Proceedings* 2845 (2021) 22–32. URL: http://ceur-ws.org/Vol-2845/Paper_3.pdf.
- [3] A. Bielinskyi, I. Khvostina, A. Mamanazarov, A. Matviychuk, S. Semerikov, O. Serdyuk, V. Solovieva, V. Soloviev, Predictors of oil shocks. Econophysical approach in environmental science, *IOP Conference Series: Earth and Environmental Science* 628 (2021) 012019. doi:10.1088/1755-1315/628/1/012019.
- [4] V. N. Soloviev, A. O. Bielinskyi, N. A. Kharadzjan, Coverage of the coronavirus pandemic through entropy measures, *CEUR Workshop Proceedings* 2832 (2020) 24–42. URL: <http://ceur-ws.org/Vol-2832/paper02.pdf>.
- [5] A. Kiv, P. Hryhoruk, I. Khvostina, V. Solovieva, V. Soloviev, S. Semerikov, Machine learning of emerging markets in pandemic times, *CEUR Workshop Proceedings* 2713 (2020) 1–20.
- [6] S. Semerikov, S. Chukharev, S. Sakhno, A. Striuk, V. Osadchyi, V. Solovieva, T. Vakaliuk,

- P. Nechypurenko, O. Bondarenko, H. Danylchuk, Our sustainable coronavirus future, E3S Web of Conferences 166 (2020) 00001. doi:10.1051/e3sconf/202016600001.
- [7] V. Tkachuk, Y. Yechkalo, S. Semerikov, M. Kislova, Y. Hladyr, Using Mobile ICT for On-line Learning During COVID-19 Lockdown, in: A. Bollin, V. Ermolayev, H. C. Mayr, M. Nikitchenko, A. Spivakovsky, M. Tkachuk, V. Yakovyna, G. Zholtkevych (Eds.), Information and Communication Technologies in Education, Research, and Industrial Applications, Springer International Publishing, Cham, 2021, pp. 46–67.
- [8] N. S. Ponomareva, Role and place of informatics in the training of future teachers of mathematics, Journal of Physics: Conference Series 1840 (2021) 012035. doi:10.1088/1742-6596/1840/1/012035.
- [9] O. Burov, A. Kiv, S. Semerikov, A. Striuk, M. Striuk, L. Kolgatina, I. Oliinyk, AREdu 2020 - How augmented reality helps during the coronavirus pandemic, CEUR Workshop Proceedings 2731 (2020) 1–46.
- [10] M. Syvyi, O. Mazbayev, O. Varakuta, N. Panteleeva, O. Bondarenko, Distance learning as innovation technology of school geographical education, CEUR Workshop Proceedings 2731 (2020) 369–382.
- [11] K. Polhun, T. Kramarenko, M. Maloivan, A. Tomilina, Shift from blended learning to distance one during the lockdown period using Moodle: test control of students' academic achievement and analysis of its results, Journal of Physics: Conference Series 1840 (2021) 012053. doi:10.1088/1742-6596/1840/1/012053.
- [12] I. S. Mintii, T. A. Vakaliuk, S. M. Ivanova, O. A. Chernysh, S. M. Hryshchenko, S. O. Semerikov, Current state and prospects of distance learning development in Ukraine, CEUR Workshop Proceedings (2021).
- [13] Decree of the Ministry of Education and Science of Ukraine from 08.09.2020 No. 1115 "Some issues of the organization of distance learning", 1969. URL: <https://zakon.rada.gov.ua/laws/show/z0566-11#Text>.
- [14] S. Kvit, O. Yeremenko (Eds.), Richnyi zvit Natsionalnoho ahentstva iz zabezpechennia yakosti vyshchoi osvity (Annual report of the National Agency for Quality Assurance in Higher Education), Natsionalne ahentstvo iz zabezpechennia yakosti vyshchoi osvity, Kyiv, 2021.
- [15] Decree of the Ministry of Education and Science, Youth and Sports of Ukraine of 13.04.2011 No. 329 "About the statement of Criteria of an assessment of educational achievements of pupils in general secondary education system", 1969. URL: <https://zakon.rada.gov.ua/laws/show/z0566-11#Text>.
- [16] K. Vlasenko, I. Lovianova, O. Chumak, I. Sitak, V. Achkan, The arrangement of on-line training of master students, majoring in mathematics for internship in technical universities, Journal of Physics: Conference Series 1840 (2021). doi:10.1088/1742-6596/1840/1/012007.
- [17] K. Vlasenko, D. Kovalenko, O. Chumak, I. Lovianova, S. Volkov, Minimalism in designing user interface of the online platform "Higher school mathematics teacher", CEUR Workshop Proceedings 2732 (2020) 1028–1043.
- [18] K. Vlasenko, S. Volkov, I. Sitak, I. Lovianova, D. Bobyliev, Usability analysis of on-line educational courses on the platform "Higher school mathematics teacher", E3S Web of Conferences 166 (2020). doi:10.1051/e3sconf/202016610012.

- [19] M. Zhaldak, V. Franchuk, N. Franchuk, Some applications of cloud technologies in mathematical calculations, *Journal of Physics: Conference Series* 1840 (2021). doi:10.1088/1742-6596/1840/1/012001.
- [20] T. Kramarenko, O. Pylypenko, I. Muzyka, Application of GeoGebra in Stereometry teaching, *CEUR Workshop Proceedings* 2643 (2020) 705–718.
- [21] T. Kramarenko, K. Bondar, O. Shestopalova, The ICT usage in teaching mathematics to students with special educational needs, *Journal of Physics: Conference Series* 1840 (2021). doi:10.1088/1742-6596/1840/1/012009.
- [22] I. Lovianova, D. Bobyliev, A. Uchitel, Cloud calculations within the optional course Optimization Problems for 10th-11th graders, *CEUR Workshop Proceedings* 2433 (2019) 459–471.
- [23] M. Shyshkina, M. Marienko, The use of the cloud services to support the math teachers training, *CEUR Workshop Proceedings* 2643 (2020) 690–704.
- [24] D. Bobyliev, E. Vihrova, Problems and prospects of distance learning in teaching fundamental subjects to future mathematics teachers, *Journal of Physics: Conference Series* 1840 (2021). doi:10.1088/1742-6596/1840/1/012002.
- [25] M. The, T. Usagawa, Effectiveness of e-learning experience through online quizzes: A case study of Myanmar students, *International Journal of Emerging Technologies in Learning* 13 (2018) 157–176. doi:10.3991/ijet.v13i12.9114.
- [26] D. Smoline, Some problems of computer-aided testing and “interview-like tests”, *Computers and Education* 51 (2008) 743–756. doi:10.1016/j.compedu.2007.07.008.
- [27] M. Gangur, Automatic generation of mathematic tasks, in: *Proceedings of the WSEAS/IASME International Conference on Educational Technologies*, 2011, pp. 129–134.
- [28] S. Rakov, M. Mazorchuk, V. Dobriak, Data processing technologies for calculating prognostic validity of educational achievement tests, *CEUR Workshop Proceedings* 1844 (2017) 388–395.
- [29] R. Tarasenko, S. Amelina, A. Azaryan, Integrated testing system of information competence components of future translators, *CEUR Workshop Proceedings* 2643 (2020) 376–391.
- [30] N. Shapovalova, O. Rybalchenko, I. Dotsenko, S. Bilashenko, A. Striuk, L. Saitgareev, Adaptive testing model as the method of quality knowledge control individualizing, *CEUR Workshop Proceedings* 2393 (2019) 984–999.
- [31] A. Mreła, O. Sokolov, Rankings of students based on experts’ assessment of levels of verification of learning outcomes by test items, *CEUR Workshop Proceedings* 1844 (2017) 289–302.
- [32] A. Abdula, H. Baluta, N. Kozachenko, D. Kassim, Peculiarities of using of the Moodle test tools in philosophy teaching, *CEUR Workshop Proceedings* 2643 (2020) 306–320.
- [33] I. Mintii, S. Shokaliuk, T. Vakaliuk, M. Mintii, V. Soloviev, Import test questions into Moodle LMS, *CEUR Workshop Proceedings* 2433 (2019) 529–540.
- [34] M. Lvov, H. Shmarova, Generation of test tasks in systems of computer mathematics for educational purposes, *CEUR Workshop Proceedings* 1844 (2017) 380–387.
- [35] N. Jiemsak, R. Jiemsak, The effectiveness of the quizizz interactive quiz media as an online self-assessment of undergraduate students to improve students’ learning outcomes, in: *2020 5th International STEM Education Conference, iSTEM-Ed 2020*, Institute of Electrical and Electronics Engineers Inc., 2020, pp. 51–54. doi:10.1109/iSTEM-Ed50324.2020.9332675.

- [36] Y. Chaiyo, R. Nokham, The effect of Kahoot, Quizizz and Google Forms on the student's perception in the classrooms response system, in: 2017 International Conference on Digital Arts, Media and Technology (ICDAMT), 2017, pp. 178–182. doi:10.1109/ICDAMT.2017.7904957.
- [37] J. Anderson, Frequent Feedback through Google Forms, PRIMUS 29 (2019) 124–137. doi:10.1080/10511970.2017.1411408.
- [38] C. Popescu, L. Avram, Good practices for online extended assessment in project management, Intelligent Systems Reference Library 199 (2021) 117–142. doi:10.1007/978-981-15-9908-8_5.
- [39] J. McConnel, “Why are we doing this?”: Using digital reflection to increase student engagement, Ubiquitous Learning 11 (2018) 13–22. doi:10.18848/1835-9795/CGP/v11i02/13-22.
- [40] G. Aras, B. Çiftçi, Comparison of the effect of reinforcement with question-answer and kahoot method on the success and motivation levels of nursing students: A quasi-experimental review, Nurse Education Today 102 (2021). doi:10.1016/j.nedt.2021.104930.
- [41] B. Pereira de Sousa, Engaging students in the evaluation process using co-creation and technology enhanced learning (CC-TEL), CEUR Workshop Proceedings 2190 (2018).
- [42] A. Domínguez, L. De-Marcos, J.-J. Martínez-Herráiz, Effects of competitive and cooperative classroom response systems on quiz performance and programming skills in a video game programming course, in: Annual Conference on Innovation and Technology in Computer Science Education, ITiCSE, Association for Computing Machinery, 2020, pp. 398–403. doi:10.1145/3341525.3387393.
- [43] A. Wildgoose, S. Bakrania, Development and implementation of rapid feedback using a cloud-based assessment tool, in: Proceedings - Frontiers in Education Conference, FIE, volume 2017-October, 2017, pp. 1–6. doi:10.1109/FIE.2017.8190602.
- [44] J. Nielsen, Usability engineering, Academic Press, New York, 1993.
- [45] O. M. Spirin, T. A. Vakaliuk, Criteria of open web-operated technologies of teaching the fundamentals of programs of future teachers of informatics, Information Technologies and Learning Tools 60 (2017) 275–287.
- [46] T. A. Vakaliuk, Criteria for selecting a cloud-based learning support system as a part of cloud-based learning environment for bachelor's degree in computer science, Zhytomyr Ivan Franko State University Journal (2017) 27–32.
- [47] Kahoot, 1998. URL: <https://kahoot.com/>.
- [48] Classtime, 1997. URL: <https://www.classtime.com/uk/>.
- [49] Quizizz, 2015. URL: <https://quizizz.com/>.