

DIGITAL TOOLS AND PLATFORMS FOR ONLINE TEACHING MATHEMATICS IN PRIMARY SCHOOLS

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Abstract: *The paper presents the results of a preliminary research about the digital tools and online platforms which can be used in teaching mathematics online in primary schools. Special attention is given to identifying the tools which provide the possibilities for formative and summative assessment of students, as well as implementation of gamification and Game-Based Learning. Recommendations for teachers based on the existing literature and experiences for using the tools are also provided. The presented research will continue under the project "Digital games in the context of learning, teaching and promoting inclusive education".*

Keywords: *Online teaching of mathematics, digital tools and platforms, Microsoft Forms, Kahoot!, Matific, Loomen Nearpod, Digital games project*

1. INTRODUCTION

The "National curriculum for primary education" is the initial document for compulsory education in the Republic of Croatia, which enables the development of basic education competencies essential for the realization of personal potentials, continuing education and lifelong learning. One of the goals of the new curriculum is to modernize teaching. Curriculum guidelines suggest replacing the traditional methods of teaching by a modern constructivist approach, which involves student-based teaching and includes interaction with students [1]. This approach develops children's potential for linking relevant information, facts and enhancing the creative and active aspects of learning. In contrast, the traditional approach is based on using textbooks, learning through memorization and recitation. Traditional approach seems to have a number of limitations when developing critical thinking, problem solving and decision-making skills in students [2], [3].

Currently, the educational system is implementing an experimental phase of curricular reform named "School for life" (in Croatian, "Škola za život"), which places emphasis on acquiring knowledge, developing ability and willingness of students to solve problems, making decisions, metacognition, critical thinking, creativity and innovation. Students should be trained for communication, collaboration, information and digital literacy, and the use of technology. The main goals of the experimental program are to enhance problem solving competencies of students, to increase the satisfaction of students with the school and the motivation of their teachers [4].

However, this new approach to education faced its first obstacle in an unexpected situation due to the COVID-19 pandemic which resulted in developing the emergency eLearning protocols [5] in countries all over the world. Due to the COVID-19 pandemic situation, and the suspension of direct teaching, Croatia switched to online teaching "overnight".

Although the Croatian Ministry of Science and Education (MZO) responded quickly by organizing TV classes and creating recommendations for teachers, as well as the fact that many teachers were trained for at least basic use of information and communications technology (ICT) in teaching through the "School for Life", there were still some difficulties. One of them was related to the selection of appropriate digital tools and online platforms for learning and teaching, suitable for different school subjects. The main problems were related to the lack of evidence which evaluates each tool or platform and recommends the best possible option for teachers' and students' needs.

This paper emphasizes on teaching of mathematics and describes the digital tools and platforms used by primary school teachers. The aim of this preliminary research is to critically evaluate tools and platforms to state advantages and disadvantages, especially in relation to the formative and summative assessment of students and the possibility of implementing gamification and Game-Based Learning (GBL). Recommendations for teachers based on existing literature and experiences for using those tools are also provided.

This research will continue within the scientific project “Digital games” so the possibilities of using games for improving motivation for learning mathematics in primary schools will be further investigated.

2. TEACHING SUBJECT OF MATHEMATICS IN CROATIAN SCHOOLS

Following fast development of computer sciences and importance of mathematics in every aspect of education, and in line with the “National curriculum for primary education”; in 2019, MZO published a new “National curriculum for the teaching subject of Mathematics” with detailed learning outcomes and guidelines on teaching and learning in a field of mathematics in elementary schools [4]. This was crucial for mathematics education since studies reported that using modern technologies early in education has revealed improvements in students’ achievement [6]. Recent studies also supported learning numeracy by stimulating and creative applications (apps) as well as by using elements of gamification and GBL to engage students. Such approaches promote learning much more than using traditional approaches to learning. For example, the first gadget used in Croatian elementary schools were tablets, which seem to be intuitively designed for educational settings such as elementary classrooms [7], [8].

New guidelines from the curriculum suggested that teachers may have more autonomy in organizing and developing lessons. They are allowed to adjust the order of teaching lessons to achieve learning outcomes as well as use different tools, according to their preferences, for the purpose of producing interesting and motivating contents for their students. In line with this, at the beginning of the school year the majority of teachers organised their lectures differently than previous years, according to needs of their own students. However, following emergency protocols, some teachers possibly found themselves having problems due to the result of “open hands”. As already mentioned, the suspension of direct teaching due to the COVID-19 pandemic situation forced teachers to start online teaching. Croatian MZO responded promptly with organizing distance teaching through TV on three channels: HRT3, SPTV, RTL2 [4]. For most of the teachers, the order of the planned teaching lessons was not the same as for the lessons provided on TV distance teaching.

Distance teaching through TV was complemented by work materials - assignments and activities for students, available online on “School for life” webpage. Therefore, in a very short period, teachers were forced to switch to online classes and establish virtual classrooms by using some digital platforms recommended by MZO. Some of the used digital platforms were: Loomen, Microsoft Teams, Edmodo.

Chosen platform was used on the daily bases to communicate with students. In addition to online platform, teachers occasionally used other tools, recommended by

MZO or found by themselves, to support the online learning activities and assessment. Some examples are: Testmoz, Mentimeter, Spiral, Microsoft Office 365, LearningApps, Quizlet, Socrative, GoSoapBox, Kahoot!, KwikSurveys, Flubaroo, Google Forms, and Hot Potatoes [4]. Some other digital tools and platforms were used for communication among teachers, headmasters, and parents (e.g. Yammer, e-mail, Viber, WhatsApp) as well as for administration of students’ grades (i.e. e-Dnevnik).

In many situations, teachers were forced to learn through experience since they received only short description of the recommended platforms and tools while the more detailed information about the advantages and disadvantages or possible technical difficulties they might encounter were not provided.

One of the useful recommendations that teachers received was about encouraging asynchronous teaching. Synchronous teaching, such as videoconferencing, seemed to be a good option [9] at the time of COVID-19 pandemic because it was conducted in real time and all ambiguities would be discussed immediately. But, the main problem with online synchronous teaching is that this type of teaching relies too much on digital technology which requires students to be present at a specific time in a specific place, without considering external impacts such as problems with Internet or owning devices needed for online class [10]. Also, global systems such as Microsoft’s communication and collaboration platform Teams were burdened globally due to the current COVID-19 pandemic situation.

3. DIGITAL TOOLS AND PLATFORMS FOR TEACHING MATHEMATICS

As previously described, Croatian education experienced a switch to enforce full online learning in a very short period of time. This also affected the teaching of mathematics which is usually one of the more demanding subjects for students. A number of mathematics teachers decided to use some of the following digital tools and platforms since those tools are designed with some features specifically appropriate for mathematical teaching: Microsoft Forms [11], Kahoot! [12], Loomen [13], Matific [14], and Nearpod [15]. In order to encourage students’ motivation to learn, teachers more or less successfully tried to introduce the elements of gamification and GBL using selected tools.

Teachers often tried several tools “on the fly” because they would quickly give up on some and replace them with new ones. The most common reasons were technical problems, which the teachers and students were both facing, inadequacy of the tools for students or unavailability of a digital license for the full versions of tools.

This chapter gives a brief overview of several tools which have been tested for learning mathematics from 5th to 8th grade of primary school and highlights their advantages and disadvantages, with the aim of making

recommendations for future teaching in an online or hybrid e-learning model. The emphasis is on elements for summative or/and formative assessment and repetition of mathematical tasks for students.

Microsoft Forms

Microsoft (MS) Forms is part of the Microsoft Office 365 suite and it is free to use for all Croatian students and teachers [15]. Microsoft Forms has a math package that is easy to use for creating quizzes, which makes this platform popular for both teachers and students. MS Forms requires logging into MS Office 365 with a unique AAI@Edu.Hr identity that each student receives by enrolling into schools and each teacher by employment [15].

MS Forms allows the following types of question to be included in the quiz: true/false, multiple choice and essay question type. The main advantage of MS Forms is the fast feedback which reduces stress on children, but also a possibility of making exams more attractive by inserting images [16]. One of the advantages of MS Forms for teachers is detailed statistics of students' answers which allows teachers to focus on students' learning process. In addition, MS Forms can be used to design the Escape room game so that students could repeat the acquired material in a fun way and solve as many mathematical tasks as possible. For example, the goal of the game is to free the math teacher by solving all the tasks correctly.

However, MS Forms has a number of limitations. Firstly, technical issues, such as displaying images from prepared questions. Secondly, MS Forms does not allow to set a duration of a quiz. Exam duration is also an important factor of the learning process since time plays an important role in strategic problem solving [17]. Also, MS Forms does not allow creating a database of questions which means that each student has the same questions which increases the risk of cheating during an exam [18].

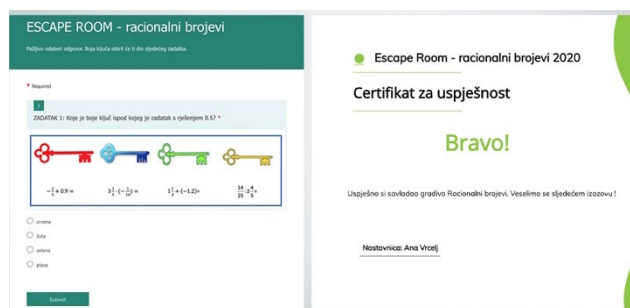


Image 1: MS Forms – Escape Room example

Kahoot!

Kahoot! is a free digital game-based tool, intended for students in various institutions. Kahoot!'s limitation is preparation for the class. Before first usage, it is necessary to download the application to the device and enter the assigned code. An important fact is that students do not

need a Kahoot! account to solve the quiz [12]. However, once a student downloads an app, every future usage of Kahoot! is very easy, which is the main advantage of this popular tool. Kahoot! offers two types of questions in the free version: true/false and choosing the multiple-choice question with one correct answer [15]. These types of questions are the most often used in quizzes or exams. Kahoot! allows insertion of an image into each question and limitation of the duration of time, which may be stressful for children, [17]. Additional advantages are work-dynamics, encouraging the competitive spirit, and learning through play.

In contrast, the disadvantage of this digital tool is that Kahoot! requires usage of one's own device (mobile phone, tablet) and Internet access, but also requires a premium or pro version for several types of questions. Using Kahoot! turns the working atmosphere very quickly into a "playroom" [19], which may result in disbalance in the working atmosphere [19]. However, the elements of gamification (collecting points for each correct answer, rank-lists of the best students, etc.) can improve the motivation of students. To conclude, Kahoot! is a digital tool which encourages social interaction among students, although giving quick feedback should be used sparingly. [20].

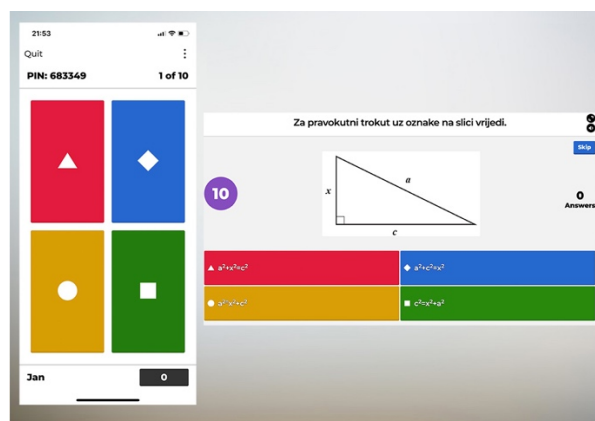


Image 2: Kahoot! Quiz screen on mobile phone and desktop computer

Loomen

Loomen is a free, open source software tool for creating e-courses, distance learning and combined live and distance teaching based on the Moodle tool [21]. Moodle is the most popular platform for online teaching used by millions of users worldwide [22]. In Croatia, to access Loomen, a unique AAI@Edu.hr identification is required. In addition to files of various formats such as websites and books, the Loomen also offers interactive elements such as forums, chats, tests, wikis and even games (e.g. Hangman, Crossword, Millionaire, Sudoku) [14].

Creating a test in Loomen allows more than 10 different types of question formats, including numerical question, and most importantly for math, it allows usage of HTML

editors and LaTeX notations [14]. This tool offers many test settings including time limit and restrictions regarding the test access and navigation among questions which enable teacher to determine the actual knowledge of the students, compare the students' abilities, and discourage cheating. In Loomen, students may take the exams as many times as the teacher allows them [23].

Unlike the before-mentioned digital tools, tests created at the Loomen platform allow students to upload their response as an image, which allows them to scan or photograph a handwritten solution directly from the notebook. This allows students to solve mathematical problems in a traditional way, without using complex digital skills. This may result in reduced anxiety during the test and improve test results. Similar to MS Forms, Loomen software is providing detailed statistics, however, Loomen seems to be better when talking about the ability to create a database of questions. Those databases allow teachers to randomly select a number of questions [23]. The teacher has an insight into all the tests, Loomen provides statistics on how much time the participant spends on each question and how many times the participant has changed his answer.

Another advantage of the Loomen is that it was intended only for users from the Croatian academic community and was not affected by the workload of global users during the COVID-19 crisis. To conclude, Loomen is a free Croatian Moodle platform for students, which provides many features that meet the teachers and students needs [9].

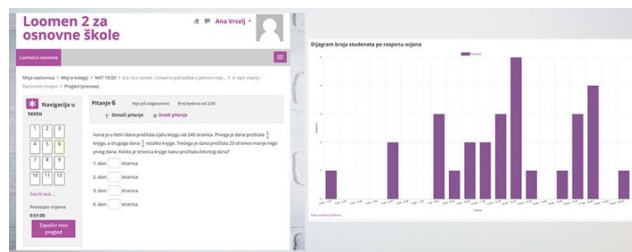


Image 3: Loomen – quiz and its statistics

Matific

Matific is a platform for online learning based on games, intended for students ages up to 12 years or until the 6th grade of elementary school [11]. The platform is intended exclusively for teaching mathematics. The platform archives progressive learning, while encouraging the development of skills and critical thinking in students [11].

The main advantage of the Matific platform is that it supports the Croatian “National curriculum for the teaching subject of Mathematics”. It also supports multilingual classes, enables offline work and synchronization. The big advantage of Matific is that it offers a possibility to constantly save the data after each modification [11]. Saving data and detailed statistics for each student reduces math anxiety and possibly increases

results of the learning process due to prevention of databases deletion [26].

The aim of this platform is to help students learn the material through various elements of the game. Matific allows students to learn at their own pace by solving worksheets, math problems or puzzles [11]. For more advanced students, bonus tasks can be added, while for students with reduced abilities, easier tasks or games can be chosen [24]. The emphasis is on developing problem-solving skills, encouraging conceptual understanding and developing self-criticism in students. Also, Matific platform contains a large number of tasks with real-life application.

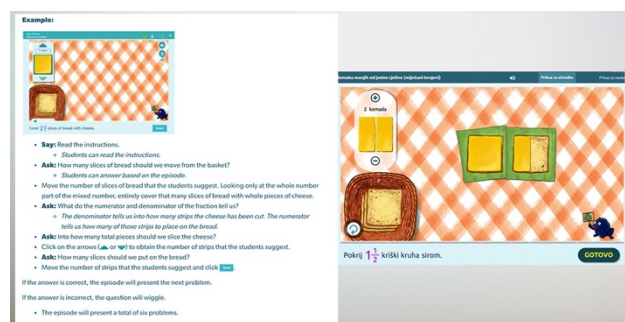


Image 4: Matific - game example

The Matific platform has very detailed statistics where the teacher can monitor the progress of students at any time of the process. Through Matific, teachers may encourage students by symbolically awarding certificates for achievements, but they can also send reports of a child's performance to the parents via e-mail. Research has shown that the use of this platform has increased student's performance [25]. Matific is generally a helpful tool, although the main disadvantages are that for usage it requires a digital license (available for Croatian teachers from the 2019/2020 school year) and it is intended for primary school students only [11].

Nearpod

Nearpod is an online learning tool for delivering interactive lessons, videos, and assessments which can be used on any device [13]. The advantage of this digital tool is that teachers have complete control over the students' devices. Nearpod prevents students from interacting with other applications during class [19].

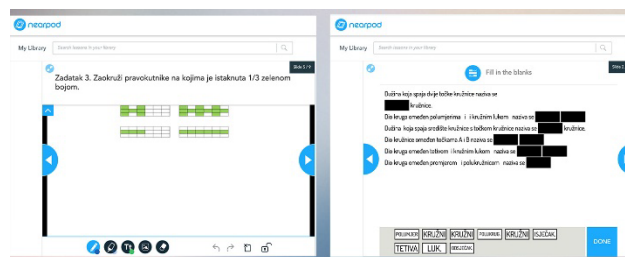


Image 5: Nearpod – quiz questions example

The software enables students to interact through various types of questions and solve problems through play and analysis [13]. This tool allows students to store all responses, but also provides response analysis, and stores responses in appropriate folders that can be used for different needs [13].

Nearpod can generate result reports for students, teacher, and parents. In addition to quality online classes, the Nearpod program allows users to create a quiz with attached images, which makes learning more interesting for students. It supports both synchronous and asynchronous modes of engaging which allows students to actively pursue literacy activities. Nearpod is a safe environment for students without any commercial ads even in a free version. To conclude, Nearpod integrates new technologies for learning and allows students to create authentic learning experiences which is crucial for their development [13].

4. FUTURE PLANS – PROJECT “DIGITAL GAMES”

The above-described preliminary research will continue under the University of Rijeka’s scientific project Digital games – “Digital games in the context of learning, teaching and promoting inclusive education” [27]. Main objective of the project is to explore the possibilities of using digital games for learning, teaching and promoting inclusive education. One of the studies in the project focuses on encouraging the integration of computational thinking into the daily teaching of different subjects in the primary school using GBL. In the context of this study, the possibilities of using games for improving motivation for learning mathematics in primary schools will be further investigated.

The experiences with teaching mathematics during the transition to online teaching described in this paper will be used as a starting point to develop digital tools, especially those based on digital games and gamification, as well as pedagogical approaches and strategies such as computer-supported collaborative learning [7], [28], [29] which will increase students' motivation and consequently enable them to better achieve learning outcomes.

5. CONCLUSIONS

The paper evaluates digital tools and platforms for online teaching mathematics used by primary school teachers, specifically in relation to the formative and summative assessment of students and the possibility of implementing GBL.

The analysis based on existing literature and experiences in using the tools and platforms has showed that each has its advantages and disadvantages. According to this, it seems that Matific is the most suitable mathematical platform for online learning through GBL (if licences are available), intended for lower grade students, while

Loomen is the most suitable online platform for students in higher grades because it enables designing tests with different types of questions and tasks. In addition, Loomen can be used as virtual classroom. Digital tools have also been shown to be suitable for occasional use while it is better to use online platforms for continuous, everyday learning.

What is currently missing is more comprehensive research on the comparison of digital tools and platforms which would help inform the teachers before use and not have them wasting time learning through their own experience. Also, there is a requirement for platforms where students are encouraged to learn and develop mathematical understanding through playing games. Because of that, this research will continue under the scientific project Digital games. It will result with the development of contemporary pedagogical-technological framework for the use of GBL and the design of digital tools as well as learning scenarios based on the framework applicable in practice for learning and teaching mathematics in primary schools. The research will use the Design Based Research (DBR) approach in order to prove the usefulness of the developed pedagogical-technological framework among students and teachers.

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