Adv Mobile Learn Educ Res, 2023, 3(1): 648-657
DOI: 10.25082/AMLER.2023.01.014

RESEARCH ARTICLE

The use of Kahoot in preschool mathematics education

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Received: December 23, 2022;
Accepted: February 16, 2023;
Published: February 20, 2023.

Citation: Xezonaki, A. (2023). The use of Kahoot in preschool mathematics education. *Advances in Mobile Learning Educational Research*, 3(1), 648-657. https://doi.org/10.25082/AMLER.2023.01.014

Abstract: During the preschool period children acquire basic mathematics skills during preschool, the foundation for their later formal mathematics education. One tool that could enhance students' mathematical skills at this age and which utilizes the elements of games in non-game settings. This study aimed to implement an intervention program to examine whether gamification affects the mathematical competencies of preschool-aged students. Thirty-one students aged 4 to 6 participated, of which 15 shaped the experimental group and 16 shaped the control group. During the intervention program, students in the experimental group were tutored through tablets and games designed in Kahoot! application and involved basic math exercises such as addition and subtraction, while the control group did the same exercises without tablets. The results of the student's performance in the experimental group showed that their performance in mathematics before and after the intervention differed significantly. Therefore, students' mathematical skills were improved through Kahoot-based learning games. It can be concluded that the application of Kahoot! Learning games can improve the mathematical learning outcomes of preschool students. Pedagogical and psychological research should be used more to improve the mathematical skills of preschoolers.

Keywords: Information and Communications Technology (ICT), mobile learning, mathematics, Realistic Mathematics Education (RME), preschool education

1 Introduction

Since the first years of their life, children begin to develop mathematical reasoning (Xezonaki, 2022). During their preschool education years, students acquire all the basic mathematical skills (Egan & Hengst, 2012), which help them adapt to their environment and acquire a range of simple and complex mathematical knowledge (Dahal et al., 2022) even though their free play, as they group, sort, measure, calculate lengths and weights, they develop relationships with their peers and place themselves concerning the space around them (Argın & Dağlıoğlu, 2020).

In recent years, the interest of the research community has turned to the use of ICT to support the teaching of mathematics in preschool education since this subject is considered particularly important for the cognitive development of preschool children (Linder & Simpson, 2018; Skaraki, 2021). New technologies are introduced every day in the technological world we live in (Barianos, Papadakis & Vidakis, 2022). Teachers are constantly looking for new technological methods to keep their students interested. In particular, when teaching mathematics, teachers face another major challenge, as students often need help assimilating and relating the mathematical concepts they are taught to the real world (Maksum et al., 2022). However, gamification is a new technological trend that proves effective in teaching mathematics. It is a methodology that uses the mechanisms and aesthetics of games and, in combination with technological means, can motivate students' actions, promote learning and solve mathematical problems (da Silva & Maran, 2020).

The value of game-based mechanisms for creating meaningful learning experiences was highlighted by Karl M. Kapp (2012), who defined gamification as "the ideal process for creating engaging learning environments" and noted its ability to build user engagement and motivation to solve problems and promote learning. However, it has been shown that gamification can contribute to increasing students' positive attitudes and willingness to learn (Landers et al., 2015). Besides, students' lack of motivation to learn has been one of the main reasons for the implementation of gamification in educational environments (Oliveira et al., 2022).

2 Literature review

Although gamification has existed in a marketing context for a long time, many argue that gamification took off when mobile technology appeared (Prince, 2013), which marked the beginning of another era in business and Education (Parapanos & Michopoulou, 2022). In

particular, the most significant technological changes have been through mobile applications due to the popularity of mobile devices (Layland et al., 2018). There is no coincidence that in recent years there has been an ever-increasing trend of using mobile applications, with the number of application downloads reaching billions (Bitrián et al., 2021).

In recent years, there has been a significant development in communication, computers and information technology. Most educational systems accept the use of information and communication technologies (ICT) and smart mobile devices in the educational process, as their use has significantly contributed to improving the quality of educational activities offered by educational institutions. In this ever-changing technological world, educators must cope with inventions and advancements to serve the needs of today's students (Raja & Priya, 2022). Because students, even in the first school grades, are now accustomed to technology, technology-based learning is considered more effective, and the study of its integration in school contexts is vital (Jadhav, Gaikwad & Patil, 2022).

Gamification is a popular assistive design used in various fields and has been gradually introduced into mobile applications to make products more attractive and practical (Yin et al., 2022). A decade after gamification first appeared, its popularity has spread to the field of Education (Swacha, 2021), where it has been applied at all levels, from preschool (Lamrani et al., 2018) to adult education (Okojie, 2020), as well as in various courses. In particular, game models were designed (Dermeval et al., 2019), specialized frameworks were developed (Swacha et al., 2020), and specific tools were implemented (Tenório et al., 2020), noting both successes (Alshammari, 2020) and failures (Hanus & Fox, 2015).

Gamification has proven to be a promising avenue for enhancing user engagement. Consequently, many smart mobile application developers are incorporating gamification mechanisms and elements into their applications to improve user experiences (Hofacker et al., 2016). Research results have shown those apps that use gamification elements, such as providing feedback or earning points for behavior, are generally rated more positively by users than apps that attempt to change behavior by providing only information (Beck et al., 2019). Gamification has been observed to offer promising potential in increasing individuals' intrinsic motivation and positively influencing users' attitudes and behavior (Treiblmaier & Putz, 2020), leading to long-term psychological engagement and other behaviour change methods such as nudging (Lieberoth et al., 2018).

In education, students' lack of motivation to learn has been one of the main reasons for the implementation of gamification in educational environments (Oliveira et al., 2022). It has been proven that gamification can increase students' positive attitudes toward learning (Landers et al., 2015). In particular, by adding a game element to the learning process, students can find fun and pleasure in it and feel that learning is an enjoyable practice and not a compulsion (Rozhenko et al., 2021). This healthy and pleasant atmosphere enhances cooperative learning, as students are encouraged to work in groups and actively participate in decision-making (Despeisse, 2018). Thus, gamification offers much more than just superficial gains provided by points, badges and levels, as it can be a valuable tool for gaining knowledge and improving critical skills such as decision-making, cooperation and communication (Dicheva et al., 2015), gradually leading to behavior change, especially when combined with student-centred teaching methods (Furdu et al., 2017).

Furthermore, gamification in Education is considered a reflective method for accelerating learning and teaching complex subjects (Ding et al., 2018), as it informs the learner about his performance during a challenge or a final situation, enhancing his participation. When it comes to teaching mathematics, studies have shown that gamification promotes students' cognitive engagement and mathematical success (Lo & Hew, 2020). Moreover, mathematics teachers prefer to include gamification in their educational practices since it has been proven that in an educational environment, gamification improves the relationship between students and the teacher and increases their sense of inventiveness (Briffa et al., 2020).

The concept of gamification is the presentation of educational content through entertainment and play (Arıcı et al., 2022). It, therefore, stands to reason that it has particular resonance in early childhood education, where it is commonly accepted that young children learn through play (Carballo, 2022). Learning through gamification can provide preschool students with a rich social experience (Qing, 2022), which has consequences for their general development and cognitive ability. Mobile gamification applications have been shown to emotionally engage preschool children and teach them emotional skills, such as stress management and anger management (Fleer, 2020), making these applications an accessible, cost-effective and attractive form of intervention (Nicolaidou et al., 2022).

Several researchers have designed and implemented mobile educational applications with game elements to enhance preschool students' mathematical skills (Papadakis et al., 2022a; 2022b). In their study, Schacter and Jo (2016) implemented Math Shelf, a math curriculum

with smart mobile devices for preschool children, based on Maria Montessori's activities and instructions (Vaiopoulou et al., 2022). They found a significant increase in the math knowledge of students who used this program at school. According to research by Lewis Presser et al. (2022), a data collection and analysis application was tested where learners were asked to apply knowledge such as counting and sorting. The study results showed that preschool students acquired new knowledge and skills and improved their pre-existing knowledge (Papadakis et al., 2022). However, it is worth noting that more relevant research was needed on the Greek data.

3 Research methodology

In the present study, we aimed to investigate more extensively the contribution of gamification to teaching mathematics and Realistic Mathematics in preschool education. The sample consisted of 31 preschool students (4-6 years old), 15 girls and 16 boys from the same semi-urban area. Through convenience sampling (Petousi & Sifaki, 2020), a non-probability sampling (Newby, 2014), preschool children who attended a public kindergarten in the Rethymno district during the 2021-2022 school year were selected to participate in the research. Two groups were formed for the present study: the experimental group and the control group. In the experimental group, blended learning was applied, which was achieved by combining learning through smart mobile devices and Kahoot! application combined with traditional forms of learning, while in the control group, activities were implemented with conventional teaching methods, based on the principles of Realistic Mathematical Education, without using smart mobile devices.

Similarly, in both groups, a test was carried out before and after the intervention with the standardized psychometric Criterion for Early Mathematical Competence of Utrecht (Utrecht Early Mathematical Competence Test) to examine the students' mathematical performance. Performance for the entire sample increased after the intervention (M = 18.65, SD = 10.51) compared to before (M= 15.90, SD = 9.86). Similarly, it happened in the control group (M= 21.50, SD = 10.48) and the experimental group (M = 15.60, SD= 9.98).

4 Intervention process

The intervention was divided into two parts. First, the pre-planned activities were carried out in the control group. Then, the experimental group used smart mobile devices to implement the intervention. Firstly, the control group was taught through the traditional method. More specifically, playful activities were designed and implemented based on the principles of Realistic Mathematical Education. In the control group's first activity on the ground mathematical level, students were asked to tackle simple math exercises to assess their knowledge of numbers and sequence. During the intervention preparation, the researcher printed and laminated the mathematical symbols = + -, as well as cards with numbers 1 to 10. In addition, she had written mathematical problems on pieces of paper, which she had folded and hidden inside a box. When implementing the first mathematical level activities, the researcher chose one child at a time, drawing a piece of paper from the box. After we read the problem aloud, the student was asked to "write" the problem in the language of mathematics, choosing the tabs and objects that the problem asked for. We then moved on to subtraction problems, which the students were asked to solve similarly (Figure 1).

Figure 1 Student places the fruits in the baskets and solves the problem

On the second mathematical level, we implemented activities in which we presented students with a random number of objects from a group of things and asked them to answer their number. In the third-level activities, kids had no visual objects. For this reason, we encouraged students to use their fingers to do calculations from the beginning.

In the first phase of teaching in the experimental group, experiential activities were developed based on the principles of Realistic Mathematical Education, similar to the activities of the control group. In the second phase of teaching in the experimental group, activities were carried out to teach Realistic Mathematics through smart mobile devices (tablets). The digital activities were designed through the gamification platform Kahoot! and the Animaker software. Kahoot! enables the designer to create fun learning games from their mobile or computer by asking a series of questions, which users answer via digital technology (tablet, laptop, mobile phone, etc.).

We had five tablets at our disposal, which we wanted to distribute equally to the students. To make this possible, we placed on each tablet a colored sticker (red, yellow, blue, green, or orange). Each tablet corresponds to the group with the corresponding color. For this reason, five groups were created, and each shared a tablet. First, we asked the children to open the tablets and find the app on the screen surface. When entering the application, the students were asked to press the button with the four geometric symbols and colors, which led to filling in the PIN of the game. Children showed no difficulty typing the game code into their tablets. After completing this task, students were taken to the application environment, where they had to fill in the team and players' names (Figure 2). At this point, the kindergarten teachers had to intervene, as the students could not type their names into the application. Some of them tried to complete their name by themselves but could not complete it.

Figure 2 Kahoot! game PIN and players' names

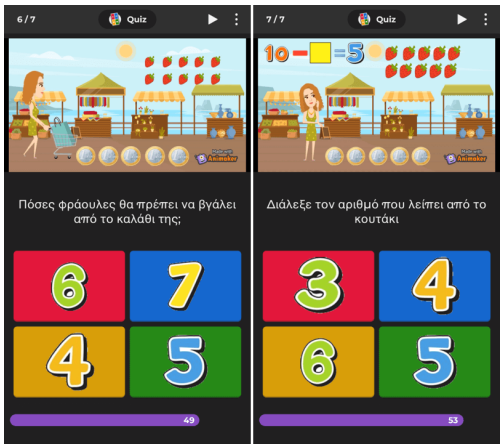
In the first question about the ground level, students were asked to count the strawberries depicted on the screen and choose the number corresponding to their quantity. In case of a correct answer, the box of the correct number turns green, while the boxes of the wrong answers turn red (Figure 3).

("How many strawberries do you see on your screen?")

Figure 3 Case of a correct answer

The first level included activities with more complex problems, where students were asked to solve by combining addition and subtraction operations. At this level, there were given four problems at the preschoolers, which consisted of two parts. In the first part, problems from

everyday life were presented, such as buying fruits from the market. Students were asked to solve it with simple mathematical addition or subtraction operations. In the second part, the problems were represented by mathematical symbols, in which a part of the operation was missing, and the children had to fill it in (Figure 4).



(Left: "How many strawberries must she take off her basket?"
Right: "Choose the missing number in the box.")

Figure 4 Example of the first level's mathematical problems

In the second level, students were given addition and subtraction math problems where the objects were hidden this time. In the first problems of the level, objects appeared before them for a few seconds and then disappeared. As the questions progressed, objects did not appear-disappear on the screen, but this time only the numbers that referred to the respective problem appeared. The problems presented situations from everyday life, such as packing a suitcase or buying cookies from the pastry shop. In particular, in one of the problems, the children heard the following audio command "*George put seven shirts in his suitcase. But his dad came, took three shirts and put them in his suitcase. How many blouses are in George's suitcase right now?*" (Figure 5).

("How many blouses are in George's suitcase right now?")

Figure 5 Example of the second level's mathematical problems

Two different stories were presented in the third level: addition and subtraction problems. In these problems, there was an unknown intermediate quantity. Therefore, to solve the problem, students should mentally perform the opposite action from the one presented in the problem. One of the third level's problems, the story occurs in a park, where an ice cream parlour sells ice creams. At the same time, the following audio message is heard: "*The ice cream man had eight ice creams. Nevertheless, the little elephant came and ate some for him. If the ice cream man now has five ice creams, how many ice creams did the greedy elephant eat?*" During the narration, the eight ice creams are displayed on the screen while the number "8" is also displayed for a few seconds (Figure 6).

("How many ice creams did the greedy elephant eat?")

Figure 6 Example of the third level's mathematical problems

A few days after the intervention, the post-test stage followed all of the children and was carried out in the same place where the pre-test was carried out.

5 Results

Table 1 presents the socio-demographic characteristics of the participants and the corresponding teaching method administered. Our sample consisted of 31 participants - preschool children. Of all the children, 16 (51.6%) were boys, 15 (48.4%) were girls, while 16 (51.6%) received a standard teaching method and 15 (48.4%) an experimental teaching method.

Table 1 Socio-demographic Characteristics of the participants

Variable	n	%
Gender		
Male	16	51.6
Female	15	48.4
Teaching Method		
Standard	16	51.6
Experimental	15	48.4

The measures of central tendency for pre- and post-intervention math performance are presented in Table 2. Performance for the entire sample increased after the intervention (M = 18.65, SD = 10.51) compared to before (M = 15.90, SD = 9.86). Similarly, it happened in the control group (M = 21.50, SD = 10.48) and the experimental group (M = 15.60, SD = 9.98).

Table 2 Measures of Central Tendency and deviation for mathematics achievement variables

Variable	n	Min	Max	Mean	SD
Math Performance (pre)	31	3	37	15.90	9.86
Standard Teaching Method	16	5	37	19.44	10.22
Experimental Teaching Method	15	3	30	12.13	8.18
Math Performance (post)	31	2	38	18.65	10.51
Standard Teaching Method	16	7	38	21.50	10.48
Experimental Teaching Method	15	2	35	15.60	9.98

A two-way mixed methods ANOVA 2 was applied to examine differences between measurement time (before-after) and between the two groups (standard–experimental) (Table 3). As mentioned earlier, condition testing was done where normal distribution was found in all conditions.

Table 3 Mean performance values for pre- and post-intervention for the control and experimental groups

	Teaching Method		
	Standard	Experimental	Total
Math Performance (pre)	19.44 (10.22)	12.13 (8.18)	15.90 (9.86)
Math Performance (post)	21.50 (10.48)	15.60 (9.98)	18.65 (10.51)

In conclusion, during the second measurement, the performance increased in all the children, while no differences were observed between the control and experimental groups. However, it is worth noting that the statistically significant predominance of the control group in math performance before the intervention levelled off after the implementation of the intervention, where no statistically significant differences were found. On the other hand, the results showed that the mathematics performance of the experimental group between before (M = 12.13, SD = 8.18) and after (M = 15.60, SD = 9.98) the intervention is statistically significantly different. The experimental group, after the intervention, improved their performance compared to the pre-test.

6 Discussion

The present study aimed to investigate the influence of gamification and smart mobile devices on mathematics learning in preschool children. Our research focused on teaching concepts based on the theory of Realistic Mathematics Education combined with ICT and the gamified application Kahoot! For this research, the sample was divided into two groups to compare their performances, as different teaching methods were applied to each group. In particular, the control group was taught with the traditional teaching method, while the experimental group was taught using smart mobile devices and Kahoot! application.

The research results showed that despite having a statistically significant prevalence in their performance before the intervention, the control group managed to maintain a balance in their performance, as they did not show statistically significant differences in the post-test. At the same time, it is worth noting that a statistically significant difference was observed in the experimental group's performance before and after the intervention. On the one hand, this difference may be due to the time interval between the two performance measurements, during which the children acquire new knowledge. However, this fact does not negate the effectiveness of the teaching intervention, during which the Kahoot! The application was tested.

At this point, it is essential to mention that the experimental group students, although they were familiar with the use of tablets, as they are devices that have and use in their daily lives, it was the first time that they used such devices in their learning. Although the school had technical equipment (a computer corner and a projector), preschool teachers rarely used these devices in their educational process, preferring to follow traditional teaching methods. This reaction of preschool children proves that what is reported in the research about stimulating children's interest offered by smart mobile devices (Papadakis, Kalogiannakis & Zaranis, 2016) and gamification applications (Rozhenko et al., 2021) is valid.

In addition, the results of our research support the position of Setiawan & Soeharto (2020) regarding the increase in students' motivation for teaching mathematics through the use of gamification and Kahoot! (Vaiopoulou et al., 2021). Through this application, the student's actions followed the educational goals, as they effectively participated in their learning process. Peers cooperated and discussed in order to make decisions and solve mathematical problems. These actions follow student-centred teaching methods, such as communication and collaboration, which are additional advantages of gamification when applied in Education (Dicheva et al., 2015; Despeisse, 2018; Kalogiannakis & Papadakis, 2017). Furthermore, our research findings are consistent with the results of Kahoot! for teaching mathematics by Umboh et al. (2021), who also found a difference in students' mathematical performance before and after the intervention.

The use of game elements in Education is often argued to be something other than the result of serious work (Papadakis et al., 2021; Papadakis, 2022). However, this study demonstrated that learning based on the gamified application Kahoot! indeed brought remarkable results in student satisfaction. However, we must mention that the teacher's role is critical to creating an attractive learning environment that actively involves all students. Making this possible requires careful planning and a sustained amount of time to prepare (Drolia et al., 2020).

The present study makes a significant contribution to teaching mathematics through gamification and smart mobile devices in early childhood education; however, further research applying gamification in this context needs to be conducted.

Conflicts of interest

The author declares that they have no conflict of interest.

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