TYPES OF MOBILE EDUCATIONAL GAMES FOR CHILDREN IN PRIMARY SCHOOL

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Abstract

Today's children, representatives of the so-called Generation Z, are constantly using the latest information and communication technologies in their daily lives (games, training, social communication, etc.). They even feel more confident using a mobile device rather than a personal computer. In addition, no matter of the environment, games prove a strong motivator in education for every generation which is utilized by educators. Therefore, according to the authors, the integration of games in a mobile environment is the most appropriate approach to enhance the learning motivation of this generation of children. The authors' ultimate research goal is to create a package of mobile mathematical games for primary school education and to test mobile applications with 3rd grade students.

The article begins with an argument about the place of games in training and the relevance of different types of so-called serious games. This paper presents the views of other scientists on the topic of games in the educational process of primary school children, as well as classifications of educational games for this age group according to pedagogy specialists.

With the development of modern information and communication technologies, a number of the well-known didactic games have been created as computer games. They are successfully used both for the realization of cognitive activities and for motivating children to study and support the understanding of the educational content. This article presents a study of the sources of educational games for Bulgarian children, as well as an overview of the existing educational computer games for children, mainly in the Bulgarian language, for mathematics and Bulgarian training.

This paper offers a reasoned conclusion, about which mobile operating systems should develop gaming applications, based on statistics for the used mobile operating systems worldwide and in Bulgaria. The results of the study on existing mobile educational games for children are briefly presented, and it is found that the number of games in Bulgarian is small while the variety of English games is large, which proves inappropriate for children because of the language barrier.

The article presents a classification of game types suitable for mobile implementation in primary school mathematics education. There are 13 types of games available that are suitable for children in primary school mathematics, as well as for mobile implementation. Each type is visualized with a real-life example of a 3rd grade mathematics textbook in Bulgaria.

An approach for creating a software package with mobile games to support the teaching of mathematics students in primary school is presented. The games will be able to be used for self-study at home, with children solving tasks by playing on their own mobile device or at school if the teacher wishes to use the new technologies in the classroom. This game-based approach for learning through mobile games aims to further develop students' mathematical skills and to offer an entertaining environment where learning is easier and fun even for children who do not fancy mathematics.

Keywords: mobile learning games, game-based learning, serious games, mobile applications.

1 INTRODUCTION

Today's Generation Z children are open to the world and are quickly accustomed to the changing information and communication technologies. They easily use various modern devices (computer, laptop, tablet, smartphone, etc.). Children use the Internet from a young age for a variety of activities - playing games, watching videos, searching or sharing information, communicating with friends, and so on.

In addition, the current generation of children takes a different approach to learning - they are active, searching and demanding. Learners want attractive training through the latest technologies and tools. They tend to learn from different sources like questionings, findings, constructing, interaction and

having fun [1]. That is why contemporary training has to change or adapt the pedagogical methods, approaches and strategies and use the learners' technologies. Modern children prefer mobile learning, especially with smart phones, to the traditional form of e-learning using a personal computer. Smart phones and other mobile devices have a number of benefits when using training such as accessibility anywhere, anytime, personalization, own pace of learning resources, easy communication and collaboration with other participants in the learning process, etc.

Games are an important part of every child's life. The fact is that games have a strong motivating force, regardless of the age group, which causes the player to strive to win, even if he /she has to repeat the game over and over again. Therefore, it is no coincidence that the gamified approach is rudimentary in the methodology of teaching children from preschool age and in the initial stage of education. Pedagogy has long emphasized the role of games in teaching and nurturing through which children gain new knowledge and skills while having fun.

The purpose of the article is to present a study of existing training games (including computer and mobile gaming applications), based upon which a classification of games suitable for mobile conversion for children in the early stages of education is presented together with the criteria and approach for creating a mobile educational games package for children in this age group.

The methodology used is presented in Section 2 and the results obtained in Section 3. Section 3 begins with an examination of the role of games in learning, and in particular in primary school age, as well as existing classifications of games. After that, a study of the computer and mobile educational games applications for children market is shown. The classification of the types of educational games in terms of their use in teaching mathematics to children in the primary school stage and suitable for mobile realization is presented. Finally, the section describes the approach chosen by the authors to create a mobile education math package for children in the 3rd grade. The article ends with a conclusion which focuses on the contributions of the study's authors.

2   METHODOLOGY

The authors' main goal is to create a suite of mobile mathematics educational games for children in the early stages of education, with the help of which students can develop mathematical skills independently while having fun at home with their mobile device. In the end the authors intend to conduct their experiment with 3rd grade students.

The applied methodology is as follow: state of the art, creating a classification of game types assignments, design of the game mobile software applications, development of the software applications, selection and filling in the applications with concrete mathematical assignments, testing the mobile applications with real learners (10 years old). The paper presents the first two steps of the chosen methodology.

3   RESULTS

3.1   Games in education

A game is a physical or intellectual form of social or individual activity organized following specific rules. Through the use of games students can acquire knowledge and skills in any subject matter. The game is the focus of attention, analysis and development of many prominent scientists in the field of pedagogy and psychology, such as H. Spencer, K. Gross, St. Hall, Z. Freud, K. Buehler, et al.

More recently, "serious games" (games used for training) have been increasingly used as a teaching approach in various educational levels, institutions and organizations (not just in the field of education). They are used in various forms: game-based learning (Gamed-based learning) by using video and electronic games to achieve learning goals; Gamification of learning by integrating game elements and techniques into the learning process; Organizational-dynamic games for training dynamics in organizations at three levels (individual behavior, group behavior and cultural dynamics); Simulation games for learning different skills by playing in artificially created environments that recreate both real-world and unreal storylines; Edutainment for simultaneous learning and fun, etc. [2].

On the one hand, the use of games or even just some of the game elements and techniques (as in gamification) [3] aims to make complex theoretical learning more accessible. On the other hand,

practical activities in games and their repetition lead to a deeper understanding of the learning content [4].

Serious games can be fun, even though they are primarily aimed at training or refining a practice. This is probably the reason they are so readily accepted by learners at every educational level.

3.1.1 Games in the learning process of children in the initial stages of learning

According to the "principle of activity approach" of Russian psychologists S. Rubinstein and A. Leontiev, for each age period there is a certain type of activity that is crucial for development [5].

Educators recognize the game in a purely didactic sense - to consolidate knowledge or to develop skills that correspond to educational content in different educational fields. According to [5], because learning is happening at an earlier age, games can have a fundamental contribution to the education of children between the ages of 3 and 10, if not with a leading role, at least with a dominant one.

Educational games enable students to study and have fun at the same time [6]. The game provides pleasure and joy to every child. But it is also a key vehicle for his intellectual, moral and aesthetic upbringing. Each game contributes differently to the development of some of the learner's cognitive processes (perceptions, ideas, memory, imagination, thinking).

While in preschool age, games are a formative force, in the primary school stage, games become an accompanying activity, since they help, strengthen the learning process. According to [7], in the life of the child in the elementary school period, games are seen as an incomparable mediator in integrating the child into learning, enriching his/her willingness to engage in different cognitive activities, stimulating cognitive interests, as well as building cognitive learning strategies. As students play, they spontaneously adopt various algorithms to perform more general cognitive and specific practical actions.

Gamified methods according to [8], applied in the joint action with the teacher and student, contribute: to activate the students; to improve the quality of knowledge, skills and attitudes; to stimulate the development of critical and self-critical thinking, their creative abilities; to form positive motivation and cognitive interests, a positive attitude towards learning and mental work; to stimulate competition between students and / or groups of students, to develop teamwork skills; for the development of students self-regulation, self-control and self-assessment; to acquire collectivist skills; to build responsibility, respect and evaluate the success of partners.

The gamified approach has already been applied in the traditional textbooks in Bulgarian schools (e.g. mathematics textbook for 3rd grade by V. Angelova [9].

3.1.2 Classification of educational games

According to the purpose of the elementary school games, [10] it presents the following classification:

– didactic game - solving learning tasks and learning certain educational content;
– mobile game - tasks for motor culture;
– music game - solving tasks related to music education;
– play-dramatization - games based on fairy tales and puppet theatre;
– story-role-playing - a game based on a familiar real-life story ("Family", "Shop", etc.);
– computer, electronic and mobile games.

According to [8] games can be sensory, symbolic, applied, musical, mathematical, design, creative and more.

[11] divides games into two large groups, which contain the relevant subgroups of games:

– creative games (story-role, dramatization, constructive and directorial);
– games with rules (didactic, mobile, didactic and music).

In our opinion, computer, electronic and mobile games do not provide a new type of game, but just another environment for its implementation. These games fall into one of the above types, depending on their purpose. The math assignments that will be completed by the team fall mainly into the didactic games group.

Didactic games are mainly used as a training approach. They can be used to consolidate, systematize and summarize teaching material, to form skills, to aesthetically, emotionally and educationally influence [11]. They use didactic material designed to set specific educational and educational goals. Didactic games do not merge with learning, but retain their character of games, which is why they are an attractive activity for children, corresponding to their age peculiarities and interests, which entice them and awaken their active participation.

3.2 Computer and mobile educational games for children

Preschool and early stages of education are difficult for both educators and young learners who need to change their main activity from playing to studying. At this age, students easily lose concentration and find it difficult to focus for long time. Therefore, subconscious learning in the process of playing games, a natural activity for students, is suitable. The use of game approaches, especially integrated with the use of appropriate information and communication technologies, will make this transition more enjoyable and easier for learners and will achieve better learning outcomes because they will use their natural environment - with a computer or mobile phone on the Internet.

3.2.1 Educational computer games

The development of modern information and communication technologies allows a number of well-known didactic games to become computer games, which can be successfully used both for the realization of cognitive activities and for motivating children to study activities and to support the learning content. The use of educational computer games has a positive effect on the development of the child, especially in the development of thinking, generating skills for generalization and classification, development of memory and attention, coordination and motoric actions [12].

[13] adds other useful skills that can be developed with the help of computer games: unobtrusive mastery of computer technology; ingenuity; activity and initiative; decision making in critical situations; goal setting and pursuit; planning and implementation of plans, etc.

Researchers [14] have found that sources of educational games for Bulgarian learners are most often specialized sites on the Internet, professional groups and blogs on social networks, as well as some educational games, a product of Bulgarian and foreign textbooks. There are already a number of interactive educational portals (mainly in English) that offer multimedia educational games, didactic assignments and exercises, songs, animations and other attractive activities on different topics and targeted at different age groups.

Several computer games in Bulgarian have been studied, mainly supporting the teaching of Bulgarian language and mathematics: "Smart Kids", "Travels in Europe", manicheta.com, "Pismenka", "Bukvenka", "Cifrenka", "Conversation", "Handwriting", "Gift of the Heart", "Owl" and more, as well as the visual programming languages Scratch and Kodu.

In recent years, Bulgaria's primary education has made the first steps to use games in a slightly different context - visual programming in the Scratch environment [15]. Kids build programs themselves through coloured blocks - collecting and arranging simple instructions in a game context to obtain more complex objects to execute instructions. The goal is to help develop "computational thinkingg" so that they can solve problems by dividing them into smaller parts, which are more easily solved, etc.

3.2.2 Educational mobile games

Training today follows the trends of information and communication technology development, in addition to traditional forms of training, innovative forms such as mobile learning (use of mobile devices and technologies in the e-learning process) are applied [16]. Mobile learning is part of a new landscape [17], and it provides many opportunities for personal, informal, spontaneous, and situated learning. By combining both mobile learning and mobile games, it will provide the user with a new experience like no other [18]. Through the use of mobile devices, students of all ages levels and backgrounds will be able to collaborate, engage and learn in different ways [17]. According to [19] research in mobile education is mainly focused on providing educational content as a complement to formal schooling. The increasing use of mobile education inevitably creates the need for the introduction of new standards and an evaluation system for the educational value of mobile apps [20].

A study of the experience of children up to 8 years in the use of digital technologies shows that: children start using these devices at 3-4 years of age; tablets and smartphones are kids' favourite

devices (who have access); children quickly learn basic skills, as some of them are not only passive consumers but actively create their own content; and almost all children use the devices for entertainment only [21].

The selection of good learning applications for children is important because previous studies have shown that their learning performances could be disappointing without proper guidance or learning design [22].

[23] presents statistics according to which the largest share of downloaded mobile applications are freeware and the most numerous of downloaded applications are games.

An analysis [23] of applications suitable for mobile education of children in pre-school has been made, and it has been established that the majority of the applications examined require a permanent internet connection. Some applications have multilingual support, but most do not support Bulgarian. In addition, the annexes satisfy the training material specified in the State Educational Requirements of the Republic of Bulgaria (DII) in only a very small proportion, most of which cannot cover even one area. The same can be said about the initial stage of education - lack of appropriate mobile educational applications, which are in Bulgarian language, in accordance with the State educational requirements, which can be applied in support of school education or during the children's free time.

Table 1. Mobile operating system market share (October 2019, Source – Statcounter) [24]

Worldwide		Bulgaria	
Operating system	Market share	Operating system	Market share
Android	76.67%	Android	88.06%
iOS	22.09%	iOS	11.42%
KaiOS	0.42%	Windows	0.27%
Unknown	0.21%	Samsung	0.15%
Samsung	0.17%	Unknown	0.02%
Windows	0.15%	Series40	0.02%

Table 1 presents statistics on the operating systems used by mobile devices in the world and in Bulgaria, which can be concluded that mobile applications must be implemented for the development of mobile educational games in both Bulgarian and English mainly for Android and iOS operating systems.

For this reason, a thorough study only of the games for pre-schoolars and in the early stages is done, mainly on Google Play and the App Store. Most of them are in English, which limits their use because of the language barrier at this age. Most of the games are free and the rest are either fully or only part of the levels paid. Particular attention is paid to the games in Bulgarian, which are intended for training in mathematics and Bulgarian for the age group of 5 to 10 years.

66 English games have been reviewed (eg. Math for Kids, Math Challenge, Math Chef, Math Bingo, Learn and Write, Word Snack, Learning Letters Puppy, Endless Alphabet, etc.). 16 games were studied in Bulgarian language (BG Numbers; BG Pupil; Letters, Numbers, Colours; Bulgarian Alphabet; BG Letter; Speech Development; Letters; Words; BG Syllables; BG words; School game for elementary school; Math vs Undead; Letters; Bulgarian Letters; Numbers; Letters with Vitamins; and Apple).

3.3   Classification of game assignments

This section presents a classification of the game types suitable for implementation as mobile gaming applications (see Table 2) to support primary school mathematics education. To illustrate the types of math games, examples are given through mathematics assignments for grade 3 (see Fig. 1 to Fig. 7), for which the Bulgarian textbook for mathematics for grade 3 was used as a source [9]. The first practical experiment is planned for this age group of students.

The classification in Table 2 is based on the classification proposed by [25] and the recommendations for the preparation of e-resources in [26]. The classification of [25] was made in terms of computer implementation of test questions and assignments with a view to their implementation in an e-learning

environment, which makes it an appropriate basis for creating a classification of game assignments in terms of their mobile implementation.

The classification contains 13 types of game assignments that are suitable for mobile conversion, divided into 8 categories. For each type, examples are given in FIG. 1 to FIG. 7. For type 7.2. There are three examples for filling in an open answer template (see Fig. 6 and Fig. 7). For type 8.1. Open answer is not an example because this group includes all the assignments that require a free format solution.

For each type, a prototype of a mobile application will be implemented, the goal being that each assignment can be presented with several different subjects and designs. For example, selecting one of four balloons (see Fig. 1 (a)) or selecting one of four soccer balls, which are two assignments of the same type (which may even contain exactly the same meaningful information), will give each child a choice about what design they want to work with. A game plot must be provided for each design so that students are intrigued to play.

Table 2. Types of math game assignments

Type of test question / assignment	Game type
1. Multiple choice	1.1. Multiple choice of images (texts)
	1.2. Choice between parts of an image
2. Alternative answer	2.1. Alternative answer
3. Multiple choice	3.1. Multiple choice between images (texts)
	3.2. Choice between parts of an image
4. Ordering objects	4.1. Establishing order between the images (texts)
5. Matching	5.1. Matching (1 to 1) between two types of objects (text-text, text-image, image-image)
	5.2. Matching (1 to many) between two types of objects
6. Filling in fields with multiple choice	6.1. Multiple-choice fields without repeating
	6.2. Multiple-choice fields with repetition
7. Filling in fields in a template	7.1. Short answer
	7.2. Filling in an open answer template
8. Open answer	8.1. Open answer
9. Mixed answer type	Unsuitable for the age group

a) Specify the bubble that will rise the fastest by finding the largest of the numbers.
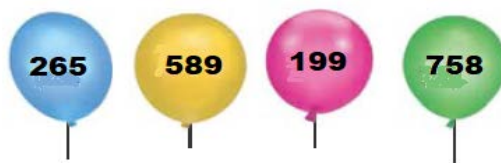
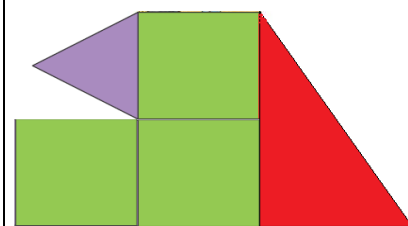b) Specify an equilateral triangle.

Figure 1. Multiple choice. a) type 1.1.; b) 1.2.

a) Is it true?

correct wrong

The rectangle has four right angles?

b) Arrange the numbers by size, starting with the smallest and you will get a word.

| 28 mm | M | 78 sm 3 mm | L | 1 m | M |

| 36 sm 5 mm | I | 99 sm 8 mm | I | 10 m | E | 900 m | E |

| 30 m | T | 90 sm | L | 1 km | R |

Figure 2. a) Alternative answer (type 2.1.); b) Ordering objects (type 4.1.).

a) Calculate and compare. Which balloons will land?

$490 - 450$
$580 - 500$
$500 + 80$
$830 - 200$
$450 + 40$
< 500

b) Indicate which triangles are right-angled.

Figure 3. Multiple choice. a) type 3.1.; b) 3.2.

a) Do the calculations and connect the traditional clothing with the correct region in the country.

$3 . 78 - 2 . 96$ $6 . (119 + 28) - 597$

$(701 - 618) . 9 + 253$ $109 . 3 + 72 : 8$ 1000 42 336 285

b) Do the calculations and see in which interval lies the answer.

Figure 4. Matching a) type 5.1.; b) 5.2.

a) Do the calculations and check whether your results correspond to the correct flower.

| 568 | .3 | +492 | .6 |

:2   :4   :5

| 284 | 852 | 213 | 846 | 141 | 705 |

| tulip | rose | daffodil | hyacinth | violet | crocus |

b) Place the correct sign.

$430 \; \boxed{\;} \; 30 < 401$

$860 > 880 \; \boxed{\;} \; 80$

$500 \; \boxed{\;} \; 4 > 504 \; \boxed{\;} \; 4$

$200 \; \boxed{\;} \; 3 > 203 \; \boxed{\;} \; 3$

Figure 5. Filling in fields with multiple choice. a) type 6.1.; b) 6.2.

a) How many of the rectangles are squares?
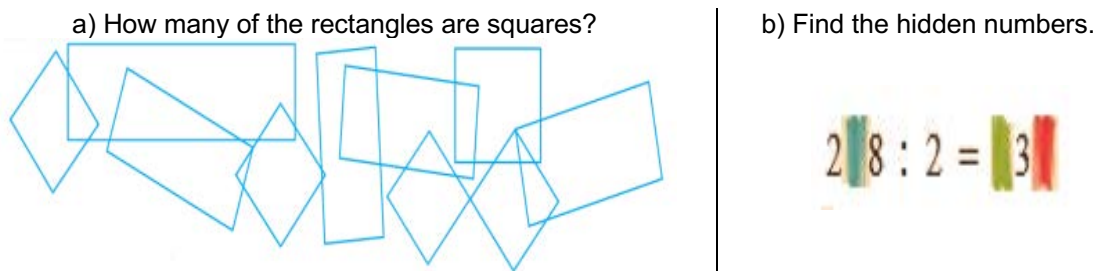
b) Find the hidden numbers.

$2\ 8 : 2 = 3$

Figure 6. Filling in fields in an answer template. a) type 7.1.; b) 7.2.

a) Fill in:

	Number of angles	Number of tops	Number of sides

b) Do the math

Figure 7. Filling in fields in an open answer template (type 7.2).

3.4   An approach for creating mobile games software

The authors' ultimate research goal is to create mobile game applications that support the work of primary school educational trainers. In order to achieve this, the following basic assignments are set, which must be carried out on the basis of the research already presented in this article:

- prototyping of various (computer-based) mobile games suitable for children (see types in Table 2);
- modification of prototypes with the ability to automatically generate multiple of the same type of games for a given prototype, but with different educational content, at different levels of complexity and for different educational sections;
- modification of prototypes with the ability to customize games with different designs from the students;
- creating and testing a package of mathematics learning games for 3rd grade students based on the prototypes created.

Based on a survey of existing games and gaming applications, it is reasonable to place the following requirements on the mobile game package created:

- the games must comply with the Bulgarian state educational requirements in terms of methodology and educational content;
- the games must be age-appropriate and therefore have a lightweight and intuitive interface;
- the games must be free of charge and also in Bulgarian;
- games must lead to achieving of some learning objectives;
- game assignments must be creative, intriguing and fun (with an interesting storyline);
- games should be relatively short in order to keep the attention of young learners;
- game applications should be interactive and animated if possible;
- gamified assignments should support the teacher's work;
- games must be autonomously usable by the children at home.

4   CONCLUSIONS

It can be concluded that gamification plays an essential role in the organization of the educational process in primary school as a pedagogical tool for training and upbringing. Through the application of gamified activities, students discover a new visually expressive, educationally impacting and gamified learning path in their studies.

The article offers a game-based approach to learning through mobile games that can develop students' math skills and offer a fun environment where learning is easier and fun even for kids who don't like math. Presented above are 13 math training game types that are suitable for mobile implementation, as well as the requirements for creating software applications that implement these game types.

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