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Teaching and Learning Basic Mathematical Concepts Based on Digital Games

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Abstract: Today all over the world the methods of teaching mathematical concepts are having a significant meaning, constantly providing an effort to the ever-changing learning needs of students. Technology has become increasingly integrated into the learning process and students must adapt to the digital age. In particular, digital game-based learning (DGBL) is being considered an effective learning tool in the classroom and beyond. Therefore, the research attempts to reflect the teaching and learning of fundamental mathematical concepts. The purpose of our paper is to present a description of how the teaching and learning of basic mathematical concepts can be handled with digital games. The methodology used for this research is a summary of existing studies, where it is discussed that through digital games teaching and learning in the subject of mathematics reflects an additional motivation for these students. The results of this study reflect a review of the literature on the need to integrate digital didactic games in the teaching and learning of basic mathematical concepts

Keywords: Technology, Digital Games, Mathematics, Teaching, and Learning.

INTRODUCTION

The learning approach is a more global way and is gaining momentum nowadays. Modern teaching tools are important and most preferred in the technological age. A modern education system uses technology to advance the education system. The increasing use of digital games and applied sciences in learning environments has impacted both teaching and learning. Digital Games Based Learning (DGBL) can be successfully used to enhance learning and teaching. Digital Games-Based Learning simply means incorporating subject knowledge into games. Students feel better about what they are learning and will try to apply the knowledge and skills gained in the future.

Game-based learning promises to diversify education, increase students' interest and motivation, and provide positive and effective learning experiences. In particular, digital game-based learning (DGBL) is considered an effective educational tool for improving education in future classes. However, learning is a complex psychological phenomenon and the effectiveness of digital games for learning cannot be taken for granted. This is partly due to a variety of methodological approaches in the literature and partly due to theoretical and practical considerations (Bertram, 2020).

The assumption many people are making is that digital games are apt to improve instruction and differentiate learning, while also providing more effective and less intrusive measurements than traditional assessments. An attractive element of the gaming experience as a learning tool is that it offers opportunities for ongoing practice because negative consequences are not usually associated with failure. Rather, failure serves as an integral part of the learning experience. This encourages players to improve through repetitive practice either by advancing within a game or by reproducing parts of a game. Failure with limited consequences, agency and choice are seen as critical elements of a true gaming experience. That is, in the context of education where a game can become a required activity associated with real consequences, there may be a reduction in these key elements that may lead students to be less inclined to practice and understand some of the benefits of gaming. However, learning does not end with play alone. Summarizing information is essential for the use of games in education, as it provides the link between learning in play and applying these skills in other contexts. Teachers can facilitate skills transfer by leading pre- and post-match discussions that relate play to other things students are learning in the classroom.

Students' experiences with play environments are shaping their expectations for learning environments. Students prefer rich graphics and multi-tasking interface. They want tasks that are "fast, active, and exploratory, with information supplied in multiple forms in parallel."Students are also more engaged when a narrative story is present within the games. Narrative is used to combine different game tasks into a coherent unit and to keep students engaged while working on different tasks.

It is important to note that by definition, games are naturally ratings. Traditional games and assessments share the basic characteristics that provide a tool to determine the amount of knowledge and skills. Both environments use complementary technologies that can be combined to create more accurate models of students' knowledge, skills and behaviors. For example, games offer opportunities for authentic and proper representation of knowledge of complex ideas, many of which seem underrepresented in traditional assessments. In games, the evaluation process takes place as the game engine evaluates the actions of the players and provides immediate feedback. Players make progress or not; they go to the next level or try again. Evaluation happens naturally in a game. The challenge is to assess the appropriate knowledge, skills or abilities (Ash, 2011). Consequently, it is argued from students' perceptions that their mathematics anxiety is likely to affect the learning environment by playing computer games (Orhani, 2023).

Much of the use of games in learning has been inspired by the assumption that games are motivating to most people. Throughout the literature on game-based learning, in the case of adults and children, it is commonly assumed that the rationale for using games to teach is that games are motivating for many people. This hypothetical motive is then used as an argument to use games to learn, the argument is that if game-related motivational factors can be transferred to learning, then learning will be more effective. In the game environment is created interactive, motivated fantasy, where the player can play, actively practice his skills. A game-based learning environment promotes to increase participants' interest and motivate participants to explore and engage in learning activities.

The relationship between math and games has often been used as a means of motivating students. Other researchers use games directly as tools to motivate students and increase their participation. Researchers' studies describe how games can be used in order to foster a positive attitude in students about math and learning in general. The study focused on the case of underprivileged students who were offered a range of competitive games that included mathematical reasoning. The students' learning took place as they participated in the games, including changing / discussing their rules of the game and discussing the strategies developed. Engaging in play can thus provide a meaningful context for students to study mathematics. In some cases, this commitment is motivated through a second learning experience.

Jonker and Wijers (2008) say that mathematics is not a subject that students are easily and naturally interested in. In this case it is necessary to use a method that would make them active. They mentioned the Th! Program. Nklets. They used it for their study in analyzing the effects of computer games on problem solving and also for motivating and attracting interest. Many study results are parallel to it (Jonker, Vincent, & Wijers, 2008).

In this regard, it is emphasized that computer games are one of the most powerful motivational tools and an aid to learning mathematics. Therefore, we can say that educational computer games are a new method to create a suitable environment for active learning, as not only students will be able to learn materials with pleasure and without fatigue, but also, they will be able to understand abstract concepts well in an electronic environment. Based on the role of computer games in increasing the speed and attention of learning mathematics, it can be proposed that students be naturally oriented towards computer games because digital games are enjoyable.

LITERATURE REVIEW

Knowledge of mathematics consists of two kinds of knowledge; conceptual and procedural. However, in the field of special education, procedural knowledge, getting the correct answer, is further emphasized by asking how students achieve the answer, the conceptual meaning. Therefore, game-based applications facilitate students' problem-solving skills with procedural and conceptual understanding of the intended content of the game-based application (Carr, 2012, pp. 269-286).

Games are effective because of the difference in presentation of single content. They are using animations for math lessons, which we can rarely find in learning materials that can improve learning, as animations or images improve the synchronization of verbal and visual information (Luzón & León, 2015, p. 27).

In one study, Pareto et al. (2011) created an arithmetic game with trainable agent aimed at training basic arithmetic skills. The game was evaluated in a study with 153 participants, consisting of students of III and V grades. The results show that the game helped students improve their math performance and self-efficacy beliefs. Ahmad and Latih (2010) describe the development of an educational mathematical game about fractions for elementary school students (Pareto, Arvemo, Dahl, Haake, & Gulz, 2011, pp. 247-255; Ahmad & Latih, 2010, pp. 17-21). According to the findings of Cerqueira and other authors (2020), the game FootMath was considered a promising and innovative tool to be included in real-life math teaching scenarios (Cerqueira, Moura, Sylla, & Ferreira, 2020, p. 6).

Çankaya and Karamete (2009) studied the effect of educational computer games on students' attitudes towards mathematics and reported a positive attitude as the achievement of the study. Demirbileka and Tamer (2010) aiming to develop a theoretical framework on the use of educational computer games in teaching mathematics, conducted a qualitative study and investigated the views of thirteen mathematics teachers in Turkey and concluded that computer games have a significant effect positive on student academic success. Grimley et al. (2011) also studied the effect of computer games on learning performance compared to the presentation method and concluded that students who are trained in the use of computer games, experience increased emotional intelligence and higher alertness, are more active, have more participation, and develop a sense of competition (Çankaya & Karamete, 2009, pp. 145-149; Demirbileka & Tamer, 2010, pp. 709–716; Grimley, Green, Nilsen, Thompson, & Tomes, 2011, pp. 45–56). Farmer (2013) tested the hypothesis that "Mathematics achievements will be significantly higher for students exposed to the iPad" Motion Math "instruction compared to students receiving traditional instruction in for mathematical concepts. The researcher compared the two groups in terms of design quasi-experimental research. The control group received traditional instructions and practiced using worksheets. Although the student in the experimental group learned in the same way, they practiced playing the game on the iPad. The study showed that the experimental groups had an average increase of 3.61, while control groups had an average increase of only 1.11 (Farmer, 2013, p. 4). Before the tests conducted in an elementary school in Italy showed a good acceptance of the game, i.e., the children liked to play the game and wanted to play again. Moreover, the researchers point out that they did not need to give any explanation to the children before the game session, therefore the game, both in its history and in its graphic, is correctly targeted. Even if the tests lasted only a few days, a very short time marked noticeable improvements in children's learning, after tests have shown that the game is able to affect the graphic representation used by children to describe fractions. For these reasons, researchers argue that a more intensive and wider use of play can support teaching and in particular fragment concepts in elementary schools (Gaggi, Ciraulo, & Casagrande, 2018, pp. 220–225). The study and reported results in the work of McLaren, Adams, Mayer, Forlizzi represent one of the few rigorous studies in the field of mathematics in which an educational game has been shown to promote superior performance in learning outcomes compared to a more conventional approach instruction that presents exactly the same mathematical content. The study in particular shows that students who learned with decimal numbers enjoyed their experience more than learning with a more conventional approach, and that students with low prior knowledge benefited more from the "Decimal Point" game than students with prior prior

knowledge. high. Thus, this study represents a major step in moving from the hope of educational games to a reality based on educational game evidence (McLaren, Adams, Mayer, & Forlizzi, 2017, pp. 36-56).
One area of significant promise in this regard is the move towards the use of educational computer games as teaching tools in schools. In response to this move, some commercial and custom-made computer games have been used in grades 1-12 worldwide to enhance students' learning experience (Wastiau, Kearney, & Berghe, 2009, p. 126). Advocates of game-based learning in higher education cite the ability of digital games to learn and strengthen skills important for future jobs such as collaboration, problem solving, and communication. Whereas in the past teachers have been reluctant to use video games or computer games in the classroom, which has a growing interest in large and diverse parts of the educational institution to see the use of digital games as serious tools of learning and assessment (U.S. Department of Education, 2010, pp. 1-124).
Students can be encouraged to share different ways of approaching a problem. Based on a review of 17 studies focused on game design, Ke (2009) concluded that instructional support features are necessary in order for lessons learned in computer games to be transferred to other contexts. Computer games can be used to create deeper learning experiences for students, but they do not provide the whole experience. Games work best when paired with effective pedagogy. As such, researchers suggest that games will not replace teachers and classrooms, but they may replace some textbooks and labs (McClarty, et al., 2012, pp. 1-36).
In an experimental design study by Shin, Sutherland, Norris & Soloway (2012), the effects of technology-based games were compared to paper-based games in a Class II. Both types of game focused on the same math skills and both groups played their game for the time being for 5 weeks. A pre- and post-test was given to determine students' achievement in relation to the mathematical skills practiced in both types of play, and the post-test results showed the game group technology significantly surpassed the card game group. Again, all students were practicing similar skills, the difference being the amount of time spent in the game. This extension showed that the more time spent on technology-based game, the better they performed in the post-test (Shin, Sutherland, Norris, & Soloway, 2012, pp. 540-560).
Despite general support for the idea that games have a positive effect on affective aspects of learning, there have been mixed results regarding the role of games in promoting cognitive gains and academic achievement. In the meta-analysis, Vogel et al. (2006) examined 32 empirical studies and concluded that the inclusion of games for student learning resulted in significantly higher cognitive benefits compared to traditional methods of teaching without games. Similarly, Annetta et al. (2009) tested the effects of educational computer games by including them in a science class in 5th grade and found significantly positive results in student performance (Annetta, Mangrum, Holmes, Collazo, & Cheng, 2009, pp. 1091-1113; Ke, 2009, pp. 1–32).
Teachers have long used a variety of approaches including contemporary media and the arts to increase classroom engagement and motivation. Perhaps the unique value of the engagement factor within digital games is the ability to support engagement and motivation over time, especially with the most challenging learning tasks and without the need for the teacher to be a "super star". Digital games can be more engaging than regular classroom activities. Although engagement can only be a component, noted Kirkpatrick & Kirkpatrick (2006), "positive feedback may not provide learning, but negative feedback almost certainly reduces the likelihood of it occurring" (Rupp, Gushta, Mislevy, & Shaffer, 2010, pp. 1-48).
Papert recounted an incident from his observations with children playing LOGO, to demonstrate how students, when engaged in creative activities that they consider fun, were unaware that they were also developing mathematical concepts. He shared his observations with a 5th grader who stated that he "hated math", yet she showed skills as a computer programmer. It took the student a whole year to discover that during the programming process she was actually performing mathematical operations and developing mathematical concepts. This incident demonstrated to Papert how a student's misconceptions

about math, self-motivation, and a sense of self-efficacy to do mathematical operations that changed as a result of the LOGO environment game (Abrams, 2006, pp. 1-24).

Joyce is a computer game which encourages players to combine numbers in different ways with arithmetic operators. It is implemented in such a way that players can play against another player online or on the computer itself. This collaborative nature of Joyce encourages the student to better learn concepts through teamwork and competition. This game mechanism encourages students to learn fractions in a dynamic group environment. It has been targeted for 5th graders and is divided into five difficulty levels. The game contains several parts like public area, private area, generating area, price area, quiz item area, exchange area and response area. This study shows that cooperative learning is beneficial, the competitive factors caused by this game can not be ignored (Feng, Chang, Lai, & Chan, 2005, p. 186).

MATERIALS AND METHODS

Mathematics is an important subject in school education. The complexity of the act of thinking and learning, as well as the relatively difficult and abstract nature of mathematics makes teaching this subject more challenging compared to the theoretical and empirical sciences. Researchers consider congestion in traditional practices, lack of modern teaching methods, lack of training equipment and tools, low cognitive stability and affective factors as the main reasons for academic failure and lack of motivation among students. One of the best ways to generate interest and motivation in students is to use computer games to improve the skills required to learn a subject. Computer games simulate real-life situations and stimulate thinking and problem solving, and through internal processes, help the learner to successfully incorporate discovery into a new situation. Therefore, success in completing a task generates interest and inclination towards the subject.

Games also meet the unique teaching and learning needs of students when new concepts are introduced as a logical progression of learning. Learning progressions are often described as the path that students take to learn a range of knowledge or skills, i.e., the sequence in which these skills typically develop. Learning progressions are often used in education. In traditional classroom settings, a student who does not master a concept may be left with a gap in his or her knowledge base that challenges subsequent attempts to construct more complex concepts. In contrast, digital games naturally force the player to master a concept in order to progress (e.g., double jumping with a line in the air to overcome the lava pit). Players are able to repeat the same scenario until they master this concept. The same philosophy can be extended to the use of digital games in education. A student cannot, in essence, solve algebra problems until a prerequisite knowledge of previous skills is acquired. However, this mastery-based lesson may require students to invest a great deal of time in learning each skill before moving on to the next. These scenarios also imply that a student has several choices and curricular control over their learning. This sense of action and autonomy for the learner is important. The most common mistake in online learning activities is to fail to provide students with an appropriate level of action. Action refers to the student's ability to interact with material and feelings of belonging and socio-emotional support in the situation. Dalton (2000) reported that 56% of students attending online courses feel a lack of interaction; they were not active elective students. Well-designed games, however, encourage students to adapt and design learning and teaching styles that are most appropriate for them, which in turn leads to a more active role in learning (Klopfer, Osterweil, & Salen, 2009, pp. 1-58).

Some theories suggest that learning is most effective when it is active, experimental, determined, problem-based, and provides immediate feedback. Game-based digital learning extends game-based learning theories by applying them in the context of a computer or video.

Game-based learning combines learning with elements of a game to create an engaging experience. Computer game applications are based on constructive theory. Computer games offer learning opportunities that involve students in interaction and help prepare them to participate in the globalized, technological environment and 21st century society (Coffey, 2017, pp. 1-3). Constructivist learning theorists (e.g., Papert, 1993; Piaget, 1964, 1970) understand that activities like play can foster deep

learning in students. This is because, in those activities, students are willing to spend more time and effort learning.

In constructivism, students face authentic problems and they have to find solutions on their own with a limited amount of instruction. Using constructivism in the classroom enhances skills. Using a constructivist perspective, it has been identified and evaluated from the current literature related to computer games, especially in educational settings. Assessing this literature, some of the skills that are incorporated by players during computer game belong to constructivist processes. Computer games help build new knowledge based on these basics. To some extent, the use of computer games shapes participants' knowledge and helps them build new perspectives on how they see themselves and how they see things they already know (Nino & Evans, 2014, pp. 1-7). Cazden (1981) defines game-based learning as performance before competence: players apply learning by doing it (i.e., playing the game) rather than learning before doing it (i.e., first reading the lesson and then playing the game) (Cazden, 1981, pp. 5-8). Game-Based Learning-based social constructivism provides opportunities for group members to integrate their prior experiences into different contexts, mixed with each individual's knowledge (Foko, 2008).

The important theoretical perspective for the analysis of learning processes in computer games is the theory of motivation. There are several ways that can be drawn to understand why computer games are often so appealing and motivating to players. The most important are constructs such as achievement motivation, social motivation, self-efficacy, interest and flow (Urhahne, 2008, pp. 150-166).

Game designers and researchers argue that games capture the player's attention and engage them in complex thinking and problem solving. For example, Gee and Shaffer (2010) show: Games require the kind of thinking we need in the 21st century because they use actual learning as a basis for assessment. They test not only current knowledge and skills, but also preparation for future learning. They measure 21st century skills such as collaboration, innovation, production and design by following many different types of information for a learner, over time. Games are often cited as important mechanisms for learning 21st century skills because they can accommodate a wide variety of learning styles within a complex decision-making context. The skills and context of many games take advantage of technology that is familiar to students and uses relevant situations. All of these can be used to highlight the 21st century skills needed to succeed in a global economy (Spires, Row, Mott, & Lester, 2011, pp. 452–472).

Furthermore, students' math self-efficacy can be improved by reducing their math anxiety, which may be helpful to them in improving their learning efficiency. Therefore, it is an important and challenging issue to propose new learning strategies or tools to reduce math anxiety in students and to promote their self-efficacy (Peters, 2013, pp. 459–480).

Overall, well-designed games, as well as well-designed education experiences, are challenging but achievable. Games should present players with challenges that match their skill level in order to maximize engagement. "The key is to set the difficulty level to the point where the student needs to stretch slightly and can complete the task with moderate support." This is similar to Vygotsky's proximal development area, which is "the distance between the current level of development as determined by independent problem solving and the level of potential development as determined by problem-solving under adult guidance, or in cooperation with the most capable colleagues" (Vygotsky, 2006, pp. 1-159).

DISCUSSIONS

We can open the discussion by showing that the expected results are that these computer games will meet all the needs of students to help them in learning mathematical concepts as easily as possible. With the development of learning games, students will learn learning content in a more attractive way, since they spend a lot of time on mobile devices, so why not learn through technology. Incorporating technology into teaching mathematics can encourage students to become active participants in the classroom. From this study can be derived direct recommendations for teaching materials in the field of mathematics for the full implementation of the Kosovo curricular framework in the integration of ICT competencies. Also, the scientific contribution from this study will find application of technology in materials and textbooks in

teaching and learning for mathematical concepts. Moreover, it is possible that the pedagogical usefulness of these computer games is not limited to mathematics, they can be easily adapted for teaching other subjects.

Computer games can break the ice between learning goals and teaching techniques, as well as reduce the seriousness of teaching so that students can freely develop creative thinking in the learning process. Thus, the most effective way to help develop these elements is to model situations that force students to think and solve problems and as a result increase attention and speed of learning.

There are many approaches to applying the principles of games in education. Computer games are virtual simulations of real-world scenarios, which serve the purpose of solving a problem. Digital game-based learning means a participatory process by students, who interact with their environment to solve the problem that is being presented to them.

The use of digital games in the mathematics teaching process, perceives the use of discursive approaches as the best teaching approach to teaching mathematics with digital technologies, at best as a complementary teaching tool. In view of this, the combination of classroom teaching and computer games may be the best pedagogy for the subject of mathematics. Digital computer games only act as supportive learning tools to complement and improve the learning process. It should be noted that digital computer games should not necessarily be adopted in the teaching and learning of the subject of mathematics in the classroom. It defeats the purpose of learning if existing teaching and learning practices are always applied with technology.

CONCLUSIONS

The findings of the study suggest that digital computer games can be very effective in increasing students' learning and satisfaction for the subject of mathematics, when they actively "think and evaluate the mathematics embedded in digital games with three factors that are particularly important in focusing students' attention on mathematics: student attitudes, support activities, and play collaborative. “The practical implications of digital games explored in this study describe ways to integrate these games into math as a means of motivating students to meet the results of this study is a positive statement of the increase in satisfaction for the subject of mathematics through the integration of appropriate digital didactic games in mathematics lessons. Then, the aim of our paper was to present the possibilities of application of the lesson based on digital games in teaching and learning math rites in lower secondary schools and inspire teachers to incorporate digital games into math education.

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