EVALUATION OF MATHEMATICAL GAMES IN TERMS OF EDUCATIONAL ASPECTS: ANDROID AND WEB APPLICATIONS

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ABSTRACT: Nowadays interactive education is becoming widespread by using smartboards and notepad computers. In addition, it is observed that by mathematical games and game assisted teaching, the attitude and success level towards mathematics are increasing day by day. Accordingly, especially in digital platforms, as in many disciplines, many games are recently being developed also in Mathematics and the children are enabled to play. However, considering that these games are not only fun aimed and they have educational aspects, these kinds of games should have some specific characteristics. In this study, the android and web applications in Edshelf and PlayStore that can be used in mathematics education were evaluated according to various criteria.

Keywords: Game based Learning, Mathematic Education, Android applications, Web applications

INTRODUCTION

Computers with a highly flexible structure can create a rich life in the process of teaching and learning through specially prepared instructional programs (Öğüt vd. 2004). Most of the mathematical concepts are abstract concepts that require cognitive efficiency at a high level. Computers can be embodied by visualizing most abstract concepts, so that most mathematical concepts can be easily grasped and become conceivable for the student and, affecting teaching and learning positively (Baki, 2000). With the widespread use of digital gaming and applications, tablet computers and smartphones are now being used effectively in technology-assisted instruction as well as computers. Indeed, almost all the young people in the Net Generation greatly enjoy using computers and spend much of their time browsing or playing computer games (Girard, Ecalle ve Magnan, 2012). In this case, using computer games in education is an irrefutable alternative, considering the opportunities that it offers (Korkusuz ve Karamete, 2013). Kebritchi, Hirumi and Bai (2010) have come to the conclusion that computer games have contributed to mathematics success and motivation without being an important influence of the knowledge, computer and English language skills. It was concluded that the opinions of the students on the motivation and teaching of computer games were positive in Kula and Erdem's (2005) study of the improvement of arithmetic processing skills of fourth and fifth grade students of instructional computer games. Girard et al. (2013) have explained that it made possible for them to think that 'Important Games' (videogames aiming to serve a useful purpose) can be powerful tools for learning, as a result of the meta-analysis. The results of Ke's (2008) study showed that computer games were significantly more effective in increasing learning motivation when compared to paper-pen studies but there was no significant effect of computer gaming on students' cognitive test performance or metacognitive awareness development.

The benefits of using new technologies in mathematics education are seen in the development positive attitude toward mathematics, interesting enhancement, reduction of anxiety, fear reduction for mathematics lessons and more importantly developmet of effective thinking behaviors such as analytical and critical thinking, as well as increasing success (Peker, 1985). Attitudes towards the subject are important factors in student academic achievement. Educational computer games comprise motivating and entertaining features of computer games and can be used as an alternative, complementary and enrichment of other teaching methods for instructional or educational purposes (Çankaya ve Karamete, 2008). Also, Aksoy (2014) supports the idea that the digital game-based teaching environment gives students a positive attitude towards mathematics lesson and contributes to the success motives in positive direction. Öztürk (2007) examined the effects of computer games on children's cognitive and affective development and noted positive results. Yılmaz (2014) found that the use of mathematics games in the study of geometric objects increased the mathematics success of 5th grade students and positively affected the attitude toward the course.

Another important factor in effective and permanent learning is that the student is active in the learning process. Today's curriculum approves the constructivism theory and according to this constitution students should actively participate in learning activities. It is believed that the use of methods and techniques in which learners will become active and that their knowledge will be constructed at their own pace is useful for teaching mathematics (Fırat, 2011). Active learning is generally defined as any instructional method that engages students in the learning

process (Prince, 2004). While there are various ways of providing active participation of the students, one of the most on the front burner of these is the technology-supported activities. The Technology-Enabled Active Learning environment was designed to support social interactions, encourage students' active learning and interest, and create a classroom climate that fosters conceptual change (Dori & Belcher, 2005). Teaching is actively involved in games as an activity that students enjoy doing in their daily lives (Fırat, 2011). Educational games ensure that learners are constantly active in the learning environment (Şahin & Yıldırım, 1999). Computer games were hypothesized to be potentially useful for instructional purposes and were also hypothesized to provide multiple benefits: (a) complex and diverse approaches to learning processes and outcomes; (b) interactivity; (c) ability to address cognitive as well as affective learning issues; and, perhaps most importantly, (d) motivation for learning (O'Neil, Wainess & Baker, 2005).

METHOD

The method of the study is determined as document analysis. A document analysis covers the analysis of written materials containing information about events or phenomena targeted for investigation (Simsek, 2009). Within the scope of this research, digital math games on Android and Web media are examined.

Study Group

The games, which can be used in Mathematics, realized with web and Android applications that covering the fractions and decimal fractions sub-learning areas constitute the working group. In total, 20 websites and Android apps on http://www.edshelf.com and the Play Store have been reviewed.

Data Collection Tools

The theoretical approaches that appear to be most relevant to mobile learning are those that involve learner control and challenge by setting an appropriate level of complexity, provoke their user's curiosity, and allow them to engage in active learning conversations. In addition to this approach, the draft secondary school mathematics curriculum and guidelines published by the Ministry of National Education of Turkey in 2017 were analyzed and the criteria to be searched were determined. Criteria have been developed to evaluate the selected educational applications and opinions were obtained from five field experts.

The obtained criteria are:

1. Grade Level and Level of Questions
2. . Inclusion of Mathematical Modeling
3. Including Different Representation of the Concept
4. Time Limitation in Games
5. Offer Clue
6. Giving Feedback
7. Hosting Motivation Source
8. Including Teacher / Parent Sections

The short introductions of the games are as follows:

1. ***Fresh Baked Fractions (https://www.funbrain.com/fract/index.html):*** In the beginning of the game four different levels are presented as options. In this game, it expected to choose the fraction among four that is not equal to the rest. The notification for the correct and wrong choices is given immediately, and when answered wrongly the correct option is shown instantly.

2. ***Braineos (http://www.braineos.com/search/tags/fractions):*** The questions include the subjects of fractions and four operations, and they are listed with headings based on their levels of difficulty. When the correct answer is congratulated, the correct answer is shown when answered wrongly.

3. ***CoolMath4kids (https://www.coolmath4kids.com/math-games/fractions):*** When classifying the games, the titles as well as the grade levels were taken into consideration. Under the title of fractions, there are five games. These five games work similarly in principle, while differ from each other in terms of game scenario and gains they deal with. Since the games are in competitive mode, speed is of importance. The sense of competition also provides motivation.

4. ***Hooda Math (http://www.hoodamath.com/games/hoodamathdefense.html):*** There are games classified in terms of grade level, category or topic. "Hooda Math Defense", which is unique to the website related to fractions, necessitates both reasoning and the ability to compare the fractions. When answering the questions, the timing is not performed. As a means to reinforce, money is gained when questions are answered correctly and this money is used for the purchasing of materials that will strengthen the defense at a later stage. In case the question is answered wrongly, clue is provided by showing the fractions on numerical line. Thus, the modelling of the fractions is enabled as well. While there is a teacher access to the website, there is no parent access available.

5. ***Studyladder(https://www.studyladder.com/student/course/mathematics?page=*&q=9):*** The fact that the games are distributed in accordance with the grade levels under the chosen titles provides great ease of use. Mathematical modeling is found in 5th grade level activities. The concept of fractions is approached for every acquisition, and meanwhile various ways of display are included. When answering the questions there is no timing, however, when returning back to the answered question the correct answer, wrong answer and the answer time are provided. The correct answer is indicated with applause and green color while the wrong answer is indicated with a warning beep and red color. In case correct answers are given and the tasks are completed, prize money is gained and with this money game character, pet animal and a home can be arranged/styled. It can be logged in with an account created by parents or teachers, and with the progress report the student can be tracked.

6. ***Braingenie (http://braingenie.ck12.org/):*** When 1-8 group is chosen in accordance with the grade levels, classification based on the titles appears. Though timing is seen on the screen, it is not for limitation purposes but rather recorded as statistical data. The clue is not provided based on the question. If insufficiency is felt in regard to the topic, there is a "watch video" button to provide the student with a summary course through a sample question. In case of giving wrong answer, the correct answer is provided together with its explanation. The timing and correct answer statistics of the members are listed and this list can be accepted as the motivator. Although suitable for an individual learning, this system can be used to duel with other users as well. There is a teacher session of the system.

7. ***Ratio Rumble (http://mathsnacks.com/ratio-rumble.html):*** The concept of fraction is deal with its "ratio" meaning, and this acquisition is provided via latent learning. Quantities that make up of the fraction as mathematical modeling are concretely displayed as elixir bottles. As one advances in the game, he is given tasks of increasing difficulty under the same acquisition.

8. ***Pearl Diver (http://mathsnacks.com/pearl-diver.html):*** The fractions are presented on a numerical line. In addition to that, as modeling there is an activity of dividing a whole into equal parts in between the levels. The fractions are defined as mixed fraction and compound fraction. There is a time limitation, the speed is of importance. As a clue, references on the numerical line are emphasized in the beginning of the game. When the wrong point is determined, the provision of the real value of that point can be considered both as feedback and clue. When the correct point is found, a pearl is gained. When a certain amount of pearls are gained at a predetermined period, the student levels up and saves money.

9. ***Math Games (https://www.mathgames.com/fractions):*** After choosing the topic to study, a selection is made among the acquisition list grouped in accordance with the grade level. Modeling is used especially in the acquisition of comparing the fractions. Different displays of the concept are used and dealt with in different aspects. Feedback is given with a star or a warning. The student is congratulated and supported even at the end of a failed stage. The student statistics are kept and the daily, weekly and monthly top 20 success list of the members is issued.

10. ***Animal Rescue (https://www.mathgames.com/play/mathsmash.html):*** First, the grade level then the subject to study is chosen. The purpose is to open the way by checking the boxes where the answers to the questions are and to save the animals. The decimal system is displayed as the different expression of the fractions. The correct answer saves the animals and saves money. The wrong answer does not result in correct answer or solution, only a warning is given.

11. ***Adding Unit Fractions (android application):*** It is aimed to create the chosen fraction by unifying three different sections of a fraction. The difficulty level of the preferred fraction is indicated with stars. The fractions are modeled and supported visually. Modeling is also the clue. It gains the skill of latently comparing the fractions. Along with that, addition and subtraction skills and equivalent

fractions knowledge are used together with the fractions. The correct answers are recorded in the solution list and this can be considered as feedback.

12. ***Fraction Mastery (android application):*** It is comprised of levels in which every acquisition from basic fraction concept knowledge to operations with fractions is dealt with. There is mathematical modeling. Correct answer is not given in wrong answers, the correct answers enable the completion of tasks necessary for passing the level, and thus the next locked level is opened. If the player wishes, he can see a clue by touching the "question mark".

13. ***Slice Fractions (android application/Turkish):*** It consists of levels grouped based on subjects with increasing difficulty. The aim is to open the elephant's path, on which obstacles appear. The game is based on mathematical modeling. The feedback is weak and if wrong path is chosen the elephant cannot move; if the correct path is chosen then the elephant can continue its way.

14. ***How Much Pizza Ask? (android application):*** It is expected to write down how much pizza was ordered in total by stating the number of two types of ordered pizza in fractions. The fractions to be calculated can be determined manually or automatically by the player. The collected fractions are modeled with pizza. Modeling is also the clue.

15. ***EG Fractionns/DEMO (android application):*** How many questions in which level will be answered within the selected skill group is determined in the beginning of the game. It includes the representation of fractions on numerical line as well as four operations with fractions. It is modeled through the display of fractions on a numerical line and division of a circle into parts while performing addition or subtraction. When answered wrongly, the chance of re-attempts is given until the correct answer is found.

16. ***Coop Fractions (android application):*** There is no level class based on grade or age. The part directed towards guessing the result of the operations with fractions is free of charge. The result of the given operation is guessed and the nest is placed at the point on the numerical line, on which the egg will fall. Based on his level, the player determines the difficulty by arranging the time limit and the size of the nest. The fractions are modeled with a numerical line. There is the display of decimal system as another representation of fractions. There is time limitation. In case of a wrong answer, the egg is broken and the value of the correct point is shown. When answered correctly, the eggs are collected.

17. ***Ethan's Fraction Game (android application):*** It is expected to determine the fractions, which were modeled with the division of the pizzas into pieces. As correct answers are given, the child runs faster and when wrong answer is provided his speed drops. The time to reach the target is recorded but there is no time limitation. The best time is recorded and the attempt to surpass this is the source of motivation.

18. ***Multiplying Fractions (android application):*** The multiplication of two fractions chosen by the player manually is calculated. The chosen fractions are shown in circle modeling. If the result is wrong the correct answer is given and when correct answer is given the player is congratulated.

19. ***Fractions to Decimals Games (android application):*** The fractions are modeled by making use of the area. It includes the decimal representations of the fractions. There is immediate feedback but correct answer is not provided.

20. ***Fractions (android application):*** It consists of levels, each of which has different acquisitions. The questions are answered until sunset, if enough success is achieved the player moves on to the other level. At each level, new spaceship is acquired and the character is improved. If wrong answer is given, the correct one seen immediately.

Table 1. Assessment of the Games Analyzed According to Criteria

Name of Game	Level	Mathematcal Model	Diff. Rep. of Conce	Time Limit	Clue	Feedback	Motivation	General Report	Tutor/Parent
Fresh Baked Fr	Four different level options	off	off	off	off	instantly	off	off	off
Braineos	off (Become increasingly diffic	off	off	off	off	instantly	off	off	on
CoolMath4kids	grade/subject	off	off	race	off	instantly/ no correct answer	on/race	off	on
Hooda Math	grade/subject	on	off	off	on	instantly/ finding the truth	on/build-up	off	tutor
Studyladder	grade	on	on	off	off	instantly	on/avatar	on	tutor
Braingenie	subject/outcome	off	off	off	on	instantly	on/statistics	on	tutor
Ratio Rumble	off (Become increasingly diffic	on	off	off	off	instantly/ no correct answer	off	off	off
Pearl Diver	off (Become increasingly diffic	on	off	on	on	instantly	off	on	off
Math Games	grade/outcome	on	on	off	off	on (support/greeting in failure	on/statistics	on	off
Animal Rescue	grade	off	on	off	off	instantly/ no correct answer	off	off	off
Adding Unit Fra	difficulty	on	off	off	on	instantly	off	on	off
Fraction Master	outcome(Become increasingly	on	off	off	on	instantly/ no correct answer	off	off	off
Slice Fractions	subject/outcome((Become incre	on	off	off	off	off	off	off	off
How Much Pizz	off	on	off	off	on	instantly	off	off	off
EG Fractionns/I	difficulty(manuel)	on	off	off	off	on	off	off	off
Coop Fractions	difficulty(manuel)	on	off	on	off	on	off	off	off
Ethan's Fractio	off	on	off	off	off	on	on/best timing	off	off
Multiplying Fra	off	on	off	off	off	instantly	off	off	off
Fractions to dec	off	on (area)	on (decimal)	off	off	instantly/ no correct answer	off	off	off
Fractions	on(level/outcomes)	off	off	on	off	instantly	on(avatar)	off	off

Windows'u Etkinleşti
Windows'u etkinleştirmek ic

Analysis of Data

The data obtained in the study were evaluated by content analysis. Data analysis can be handled in two main groups; descriptive analysis and content analysis. The main purpose of content analysis is to reach concepts and associations that can explain collected data. The meaning of the data is at the same time a subjective process, and therefore the absolute objectivity of interpretations can not be claimed (Şimşek, 2009).

RESULTS

Grade Level and Level of Questions

Of 20 games in question, 5 of them have grade selection and three of those offer subject selection. In one of them the game starts with the easy, medium, difficult and super brain selections. The difficulty in one of them is indicated with the number of stars. Three of them offer options in terms of subjects and two of those become difficult throughout the game. One of the games consists of levels, each of which aims different gains. In 2 games, the difficulty of the game is set by the player in the beginning manually. In 6 of the games (30%), there is no grade or subject selection, and three of those gets difficult throughout the game.

Inclusion of Mathematical Modeling

14 games (70%) among the ones being analyzed have mathematical modeling while 6 of them does not. The fractions are modeled through representation on numerical line in 3 of them, making use of area in 9 of them, making use of volume in 1 of them and division of a whole into equal parts in 1 of them.

Including Different Representations of the Concept

The fractions can be presented with a decimal representation via fraction bar or percentage. 16 games (80%) among the ones being analyzed do not have different representations.

Time Limitation in Games

16 games being analyzed do not have time limitation. While an answer within a limited time is necessary in three of the games, the speed is important in one of them because of a competition.

Including Clues

6 of the games provide hints to enable or make it easier to find the correct answer. In two of them the hint is given with a numerical line, and in two of them with the modeling of the fractions. In two of the games, the player can see the hint as in lecturing by pressing the button if he needs.

Giving Feedback

19 games among the ones being analyzed, a feedback is given via an indicator (sound, color etc.) that shows the answer is correct or wrong. Among four of them the correct answer is not given, in one of them the right answer is enabled to be found through elimination method and in one of them the student is encouraged via positive notifications although he fails. In one of the games there is no feedback.

Hosting Motivation Source

In 7 of the games, there are motivation resources. Motivation resources are accepted to be factors in addition to the feedbacks that connect the player to the application/game and make the game attractive. In one of the games, the competition status, in three of the games the character strengthening/developing, in two of the games the statistics are recorded and a success list is created. In one of the games, the best time is recorded and it brings the desire to break this record.

Including Teacher / Parent Sections

The usage of game and applications under the surveillance of parents/teachers and the parent/teacher platform for the tracking of student works is an important feature. However, none of the android applications in question has this feature. Two of the websites have both parent and teacher; three of them have only the teacher access.

DISCUSSIONS

Learning mathematics is getting more difficult especially in young age groups due to the difficulty of concretization. This situation causes students to build negative attitudes. Also, having active students is a point on which the teaching approaches that are accepted today are emphasizing. Game based methods are preferred so as to overcome these difficulties and due to many more aspects. In today's world, where the digital learning tools are popular, there are various math games being designed. Of course, they should be analyzed in terms of criteria in order to determine the qualifications of the educational games.

In this study, the math games with the subject of "fractions" that are present in the websites located in edshell platform and that can be accessed freely in android applications area analyzed based on the following criteria: Grade Level and the Level of Questions, Inclusion Mathematical Modeling, Including Different Representations of the Concept, Time Limitation in Games, Including Clues, Giving Feedback, Hosting Motivation Source and Including Teacher / Parent Sections.

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- Few games are categorized in terms of grade level. Considering the fact that the curricula applied in the countries are variable, it can be thought that offering choices in terms of subjects would be more suitable. Still, there are few games offering such classification.
- There is modeling in majority of the games. Because fractions are abstract concepts that indicate quantity, modeling is quite important in terms of making learning easier.
- The majority of the games being analyzed do not have different representations of the concept. "Different representation of the concept", which is significant in dealing with the concept in different aspects and perceiving it in every sense, was also emphasized in the draft education program of 2017 issued by the Board of Education and Discipline.
- There was no time limitation in almost all of the games.
- There are few games that effectively use clues, which enable the students to interpret and shape the information and are important elements of learning.
- In almost all of the games, immediate feedback (correct-wrong) is provided.
- Elements that will provide motivation so as to keep the student interest alive are present in few games.
- It is important for games to be under the surveillance of parent/teacher in terms of both safety and the tracking of the educational process. However, at this point, there are limited web games that offer this opportunity while there are no Android games in that matter.

SUGGESTIONS

In consideration with the results that emerged, it can be said that generally in the design of the educational games, the "educational" dimension is weak. It is seen that game based learning that is referenced intensively in literature and emphasized for its educational value could not keep pace with the integration of technology into the educational process. There can be studies in regard to standardizing the game criteria and it can be suggested to make designs suitable to those criteria in question.

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