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Development of Educational Math Game

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Abstract: The game is an entertainment activity where people who start with the history of humanity have a good time in their spare time. Thanks to the innovations offered by technology in the digital age, people spend their free time in virtual environments. These virtual environments are social media, news sites, video channels as well as digital games. While digital games are a favorite leisure activity for adults, young people are more likely to spend time with digital games. The educational-themed preparation of games, which are currently indispensable leisure time activities for young people, enables them to learn while having fun. It is important to develop educational digital games and present them to young people in accordance with learning. With this awareness, an educational game with mathematical operations activities was developed in the research. In the study, the developmental research method, one of the design-based research method derivatives, was used. In the research, game development stages and mechanics are explained in detail, and the technologies used are presented.

Keywords: Mathematics, Educational computer game, Design-based research, Game-based learning.

Introduction

The game is an entertainment activity where people who start with the history of humanity have a good time in their spare time. Thanks to the innovations offered by technology in the digital age, people spend their free time in virtual environments. These virtual environments are social media, news sites, video channels as well as digital games. While digital games are a favorite leisure activity for adults, young people are more likely to spend time with digital games. The educational-themed preparation of games, which are currently indispensable leisure time activities for young people, enables them to learn while having fun (Kader et al., 2019).

When educational games are used independently of the classroom environment, they ensure the successful transfer of course content (Garris et al., 2002; Turner et al., 2018). Gee (2003) argued that the principles of learning can be embodied with games, and claimed that the theory of learning is embedded in computer games. In pioneering studies on games, it has been found that students can develop more than one way of thinking about the problems they encounter while playing games (Pivec et al., 2004) and that games provide students with problem-solving experience (Squire, 2005; Pusey, 2018; Shi et al., 2019).

Thanks to the sound effects, realistic animations and three-dimensional virtual environments used in the development of computer games developed in today's technologies, they attract more attention of the players. Studies on the effect of educational computer games on student achievement are current technologies such as augmented reality (Hwang et al., 2016a; Hsu, 2017), mobile software (Tlili et al., 2015; Hwang et al., 2016b; Cheung, 2018), virtual reality glasses (Hu et al., 2016; Sternig et al., 2018) are discussed with three-dimensional games (Bontchev, 2015; Koivisto et al., 2017).

Mathematics is a field that can be supported by computer-aided studies in terms of subjects such as numbers and operations. Demir and Başol (2014), in the light of the literature they examined, stated that computer-assisted mathematics education contributed positively to mathematics achievement. One of the computer aided applications for mathematics lessons is digital computer games. There are many studies and studies conducted in our country on game development and educational effectiveness in the field of mathematics.

Tuzun et al. (2006) stated that the environment they developed to teach the subject of functions in the game environment, includes activities based on experience, these activities are based on inquiry, the student motivation is high during the activities, the students have opportunities to learn at their own pace, and the environment encourages the learners to cooperate. stated that it can be used in teaching as an effective tool. Çankaya and Karamete (2008) developed two games called Proportional Tetris and Proportional Clown with the subject of ratio-proportion in mathematics lesson. Gökbulut and Yücel Soft (2014) examined the effect of fractions in the field of mathematics on achievement and retention, and found that the game increased the academic achievement in the subject, provided permanence and increased the interest in the lesson in a positive way. Durgut (2016) developed an educational math game for vocational school students and found that playing the game increased the academic success and motivation of the students.

It is important to develop educational digital games using up-to-date technologies and present them to young people in accordance with learning. With this awareness, a three-dimensional educational game with a mathematics theme was developed by examining the studies in the field of mathematics in the light of the relevant literature review.

Students who had to stay away from their schools during the covid-19 pandemic period experienced disruptions in their education in this process. Students sometimes had difficulties in adapting to the process, could not attend online classes due to technical problems or could not enjoy the lessons they attended, thus reducing their motivation to study. With this research, it was aimed to improve the mathematical knowledge of students who were away from their schools during the pandemic period and whose motivation to study in the same way decreased, to revitalize their motivation and learn by having fun. The game, designed within the scope of the research, aims to improve the player's arithmetic knowledge and aims to teach everyone from seven to seventy while having fun.

Method

In this research, the developmental research method, which is one of the design-based research method derivatives, was used. With design-based research, tools that will facilitate learning are designed (Brown, 1992). There are two types of developmental research product or program development, which is a derivative of the design-based research method, and researching the educational aspect of the developed material (Richey et al., 2003). In this research, information is given about the development of the math game.

Unity Game Engine was used for game development and C# was used as the coding language in the game. Game mechanics is a system that includes game rules, game control, interaction between players, story transfer, player experience, game equipment, and player emotions during a game (Lundgren & Björk, 2003). Flow Theory, which was introduced by Chickszentmihalyi in 1990, is explained as the ability of the player to challenge and solve the situation in the game. The actor must be successful in order to enter the theoretical flow (Prensky, 2001; Quoted by Facer, 2004). Playing the developed mathematical educational computer game in a three-dimensional environment increases the desire of the users to respond correctly to the situations they encounter and their motivation to complete the tasks.

Results

The EFM model proposed by Song and Zhang in 2008 got its name from the combination of the initials of the words effective learning environment, flow and motivation. The main purpose of the EFM model is to increase the aspiration throughout the flow. The EFM model aims to increase motivation and increase the level of learning by keeping the student in the flow. While developing the math game for our lesson, student motivation compatible with the EFM model was taken into account.

According to the story of the game, the character student remained in school after everyone left school. The school's security guard did not notice the little boy and locked all the doors and left. The aim of the player is to

open these doors, find the necessary passwords and keycards and exit the school. Level designs are based on the logic of the player solving these puzzles with the various puzzles they contain. This game is puzzle based game mechanics consist of doors, keycards, password system, blackboard, trade, score and inventory.

Doors;

• The player has to use passwords or keycards to open locked doors.
• Door locks can consist of passwords only, keycards only, or both keycard and password.
• Unlocking a door does not grant the player anything other than access to the room.
• The player has to obtain numbers to decode the doors.

Keycard System;

Keycards consist of three stages: Green, Yellow and Red. The main gates are defined as red keycards by default, but are available in various level designs.
a. Red and Green
b. Red and Yellow
c. Red and Red

They can be designed in such a way that they need more than one keycard and additionally a password. When the player clicks on the keycard they find and presses the interaction key, the keycard is added to their inventory. When the player approaches a door that requires a keycard, he sees on the screen which keycard(s) he needs to unlock the door, and as soon as he presses the interaction key, the keycard is deleted from the inventory and placed on the door (Figure 1).

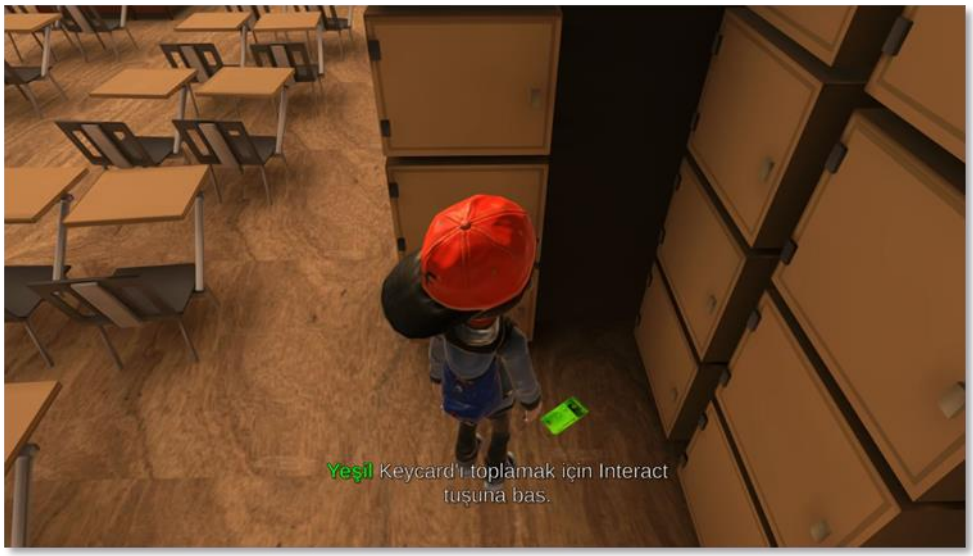

Figure 1. Unlock task

When the player approaches the door that requires a password, it warns that the door is locked and if the player presses the interaction key, the UI (User Interface) screen opens and the player enters the password using the mouse or keyboard on this screen. Passwords are the result of mathematical operations written by the designer. The designer determines the action and the result, and if the player has entered the result correctly, the door opens (Figure 2). A keypad appears on the UI screen that opens, and this screen contains buttons such as "Answer" and "Delete".

In order to enter the result of the transaction, that is, the password of the door, in the inventory of the player, there must be numbers suitable for that result. For example, "let's set the operation as 12+24". In this case, our password will be 36. If the player does not have the numbers 3 and 6 in his inventory, he cannot click on the 3 and 6 buttons on the UI or on the keyboard and receives a warning. That is, the player cannot enter a number that is not in their inventory. The player has to use the system I call BlackBoard to add numbers to their inventory.

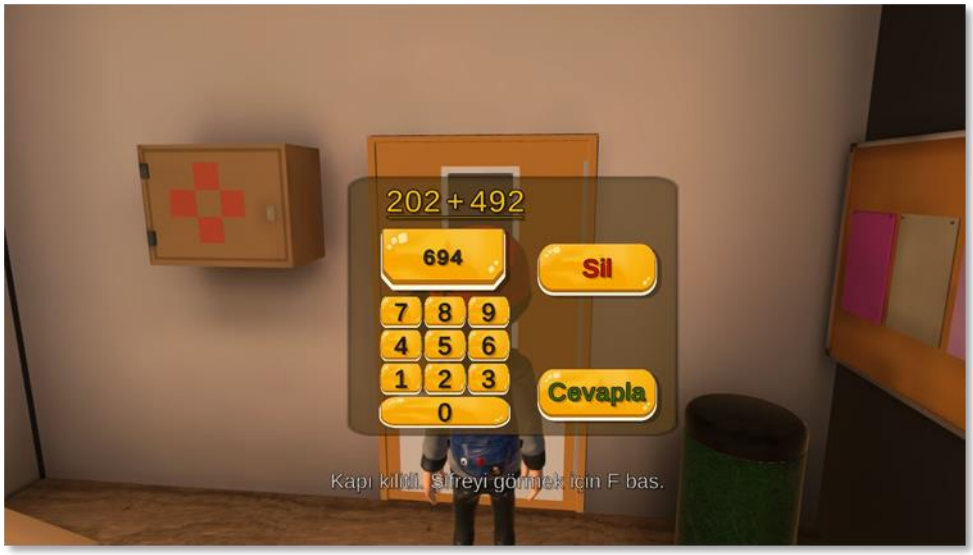

Figure 2. Password system

The BlackBoard system actually consists of only one user interface. The window that we see as a blackboard in the game and that opens when we interact helps the character to add, subtract and manipulate numbers in his inventory (Figure 3). There are 2 separate parts in BlackBoard UI. One is the "Get Issue" part and the other is the "Take Action" part.

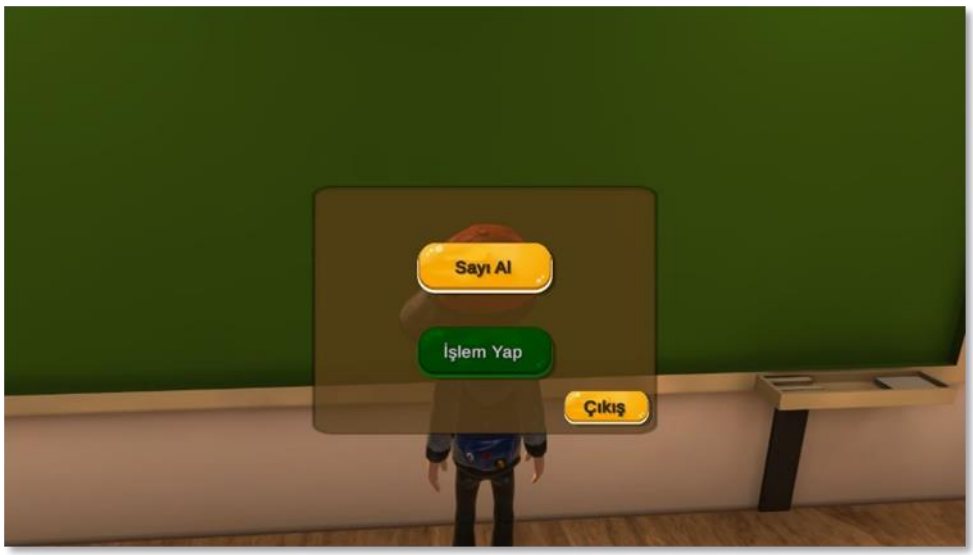

Figure 3. BlackBoard system

In the action section, the player can change these numbers by adding and subtracting the numbers in their inventory. In the small area next to the screen, he can see the number he entered before. For example, let's say there are two 8's in the inventory. By adding these numbers, he can get the number 16 or subtract 0. This allows the player to manipulate the numbers as they wish. You can make two with the number 16 you get by adding 8 numbers, 5 numbers you have one in your hand, and you can open a door with a password of 55.

In the scoring part, the system asks the player for random addition and subtraction, and the player has to enter the result on this screen, just like entering a password on the door lock. The result written here does not lead to a decrease in the numbers in the inventory. If the result is correct, a random number is given to the player, if it is incorrect, a warning is given and a random action is generated by the system again.

Inventory is the part where the numbers obtained by the player are kept (see Figure 4). In the game, the numbers in the inventory in the upper left and the keycards in the inventory appear in the lower right. There is no limit to the keycards that can be carried in the inventory. However, for numbers, this value is defined as 5 and the

designer can change this value as he wishes. The inventory capacity can be increased from 5 in the first level to 10 in the second level, or power-ups can be used to increase the capacity.

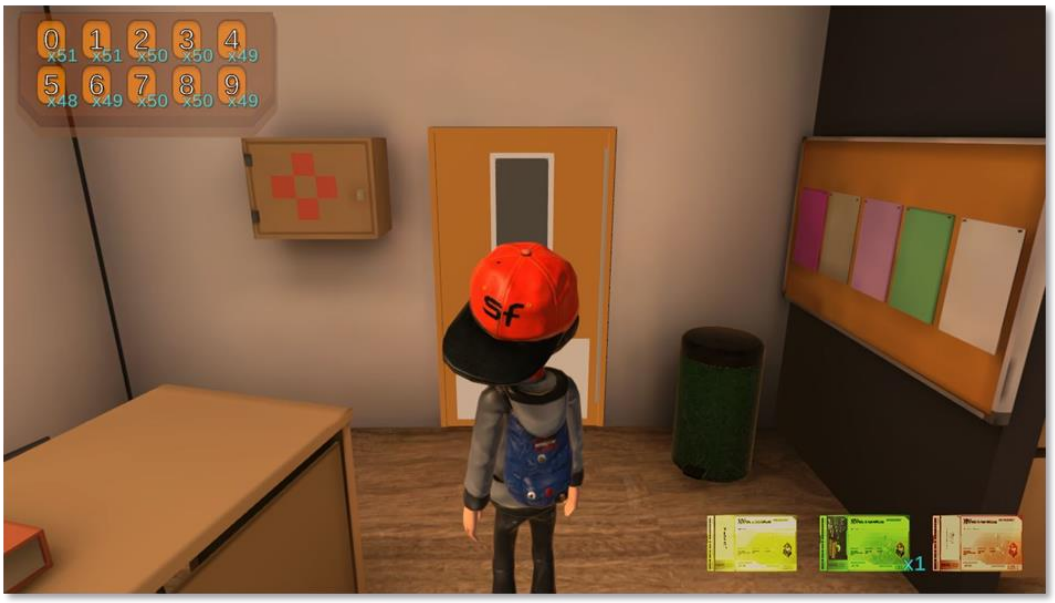

Figure 4. Inventory

Conclusion

In this study, which was carried out with the awareness of the necessity of developing educational games, the educational game developed in a three-dimensional virtual environment and includes arithmetic mathematical operations. By transfering of educational content to the user with three-dimensional games in current academic studies, there are findings of creating a desire to learn in students, student success and motivation towards the lesson (Durgut, 2016). It is thought that the features of the math game in our lesson, with its three-dimensional virtual environment and educational content, will be used to increase students' arithmetic success and motivation towards mathematics.

Suggestions for improvement in the game are presented below;

• The character can obtain a random or predetermined number from the calculators he finds in the environment,
• The character fills a guess bar by doing unfinished homework that he finds in the environment, and this bar can be made to guess the passwords of locked doors. In other words, there is a possibility that the door will be opened without decreasing the number from the character's inventory, but this depends on the fullness of the prediction bar. A fully filled prediction bar does not give a 100% chance.
• The character is rewarded with points for the door he opens and these points can be used to unlock new actions (in BlackBoard UI) in the game.

Scientific Ethics Declaration

The authors declare that the scientific ethical and legal responsibility of this article published in EPESS journal belongs to the authors.

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