

Animo Math: the Role-Playing Game in Mathematical Learning for Children

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Abstract –Presently, the advancement of modern digital technology has increasingly influenced playing and learning. This may cause serious problems in children because it possibly encourages them to obsess over something else easily. However, most parents want their children to be good in classes. Additionally, mathematics is one of the most basic skills that most parents expect their children to master. In order to encourage students to pay more attention to mathematics, the mathematical game referred as to ‘Animo Math’ has been developed for children aged 5-7 years. This game enables children to pick the cartoon animals representing themselves while playing the game. Colourful cartoon and music are utilised to attract the attention of children. More importantly, the game aims to serve children who have different ages and mathematical skills; therefore artificial intelligence (AI) is adopted. In order to develop the computer-based role-playing game, a usability testing is conducted to obtain better aspects of building this educational computer game for children. We anticipate that our research findings related to this game will encourage more educators and others to develop more software applications in order to enhance students’ mathematics learning.

Keywords – Educational computer game, Game development, Mathematics learning, Role-playing game.

1. Introduction

Parents often talk to their children about mathematics, such as when counting numbers and buying things in everyday life. Once children are old enough to be in school, parents who feel confident in

mathematics can help their children with mathematics homework. However, a rapidly changing and increasingly complex world has given most parents a busy life. Most parents have no time to help their children with their mathematics homework. Without a shred of doubt, parents often expect the school and teachers to be able to teach their children to become smart students. Many parents (45%) are willing to pay for software applications to help improve their child’s educational learning [1]. Some literature, such as Hunting et al. [2] and Clements et al. [3], have suggested that learning mathematics at a young age is important for later mathematics achievements. Therefore, most school-age children will be expected to do well in mathematics.

According to the Trends in International Mathematics and Science Study (TIMSS) 2015, derived from the works of the International Association for the Evaluation of Educational Achievement (IEA), member countries are expected to assess academic achievement. The assessment started in 1995 and is evaluated every four years. The results illustrated that Thai students in the 4th grade ranked 34th in 52 countries [4]. Moreover, teaching mathematics for children in many countries is becoming difficult in any circumstances. Teacher shortage in many subjects, such as mathematics, science and foreign languages, is a key problem in Thailand. The unusual phenomenon of a shortage of teachers in schools is a more serious challenge for Thai education. According to Puncreobutr and Rattanatumma [5], they have documented that the shortage of mathematics teachers at Thai Basic Education level is due to various reasons such as the lack of availability of good mathematics teachers, the difficulty in mathematics as a subject, and lower compensation for mathematics teachers. The consequent fact is that Thai teachers are expected to teach many subjects, even if outside their area of specialisation [6]. As a result, a large number of mathematics teachers do not graduate in mathematics. Therefore, it has become more challenging when Thai teachers have a responsibility to improve mathematics learning for their students. Many teachers and educators have studied the mathematics learning management model for

DOI: 10.18421/TEM71-17

<https://dx.doi.org/10.18421/TEM71-17>

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Received: 12 November 2017.

Accepted: 17 January 2018.

Published: 23 February 2018.

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improving creative thinking, such as Sriwongchai [7]. Also, Khun-Inkeeree et al. [8] have examined the relationship between self-confidence and mathematics achievement among 6th grade students in the southern part of Thailand.

Games also offer a good way for parents to get involved in their children's education [9]. Additionally, having students use computer games as a tool to obtain the educational skills can be seen in many professional areas of teaching. Rankin et al. [10] have addressed that playing computer games makes it possible to foster learning in the virtual world as players accomplish game tasks. Hamari et al. [11] have argued that being skilful in computer games did not affect learning directly, but it may be effective in learning challenges by increasing the engagement with the games.

The role-playing game (RPG) seems to be the most popular among many genres of games. By definition, it is a game in which a participant assumes the role of a character, which is normally in a virtual world. Players are able to interact with one another by acting as the character they assumed in the game. Moreover, a role-playing game will be beneficial for children because it helps creating more imagination. Imagination is the most important attribute that we can foster in children. Therefore, at present a game-based learning is used as a tool to build children's imagination. We also accept the truth that children at all ages prefer to play computer games. Consequently, the issues described above are the ones that motivate us in developing a software application based on a role-playing game in order to enhance students' imagination and gain more attention among students of mathematics.

There are many studies on the benefit of digital games, which have been used as educational tools for children. In Thailand, Kaye [9] has studied the factors in using digital games for undergraduate students. He also documented that digital game application in the Thai market had grown noticeably from 2003 to 2006 and continually increases year after year. Additionally, Chungthanachoenlert et al. [12] have developed a computer-based game called 'Golden Sugarcane', designed for young Thai students. The game is a competition-based game, allowing students to learn mathematics while they are playing on the game without feeling bored. An online game named 'Eternal Story' is also a well-known game based learning technique, which has been designed for fundamental English teaching at the Chiang Mai University [1]. Eurasia is also an online game for young students, which allows multiple players to accomplish the assigned missions. The game contents covers four primary-level learning subjects such as science, Thai language,

social studies, and occupational foundation and technology.

There are six parts including this introductory section. The objective and expected benefits of the paper are represented in section 2. The features of Animo Math are described in Section 3. The details of software development and interface design are described in Section 4. The evaluation of user satisfaction is shown in Section 5. The last section illustrates the conclusion and further works.

2. Objective and Expected Benefits of the Paper

The main objectives of the paper are presented as follows:

1. Develop a computer game for children at the age of 5-7 to facilitate learning in mathematics,
2. Use two-dimensional animations as a tool to gain more of children's attention,
3. Customise the academic content of mathematics into the role-playing game in order to motivate the learning in mathematics.

Expected Benefits

1. Make children more interested in positive learning in Mathematics.
2. Gain more of children's attention by using vivid cartoon and musical sounds.
3. Enable children to see the fun of mathematics.
4. Parents perceive how to use modern digital technology and computers for children in mathematical learning.

3. Important Features of the Game

For this paper, the software development of the instructional materials in teaching mathematics for children aged 5-7 years referred to as 'Animo Math' is described. The main objective of this paper is to develop a mathematical game for children. The game covers only two areas, which are addition and subtraction.

Numerous researchers documented that learning with computer games has become an important tool for teaching [13]. The important features for educational games for children recommended by Gelman [14] and Judy [15] can be demonstrated as follows.

- Applications may embed mathematics with enjoyment.
- Applications stimulate children to think.

- Applications may use pauses to allow children to think.
- Applications contain as little text as possible.
- Applications must be easy to use and interact with.
- Applications use upper and lower case letters consistency.
- Applications must use a few vivid colours.
- Applications must use highlighted words and phrases, which are easy to read.
- Clickable icons in the applications must be highlighted or differentiated in some way.

In order to develop the mathematics game that serves children who have different ages and mathematical skills, artificial intelligence (AI) is used in Animo Math. It was for searching the right mathematics level of players. Therefore, the artificial intelligence algorithm was one of the most difficult and time consuming aspects of our game. As the game is developed for children, the story of the game is very simple. Children can play and develop mathematics skills through the role play with enjoyment. Even though the game has five levels of difficulties, the game will not display the level of players in order to avoid pressure on children. If a new player is in the game, the game initialises questions with level 1, which uses only single digit numbers (0-9). This helps small children calculate single digit addition and subtraction better. If the system of the game has found that the player demonstrates fluently for addition or subtraction, the level of the game will automatically increase to another level. The numbers used for these questions will be spanned to two-digit numbers, which are between 0-20. The other levels of the game cover 0-40, 0-60, 0-80, and 0-99 respectively. More importantly, the level of players will be kept in the database in order to keep developing their mathematical skill.

4. Software Development

In order to implement the software for Adobe Flash player, the following applications are required.

- Adobe Photoshop cs6
- Adobe Illustrator cs6
- Adobe Flash 10
- Adobe Action Script 3.0

4.1 Animo Math Flowchart

Regarding the recommendation, we want to emphasise that mathematical applications may not contain all of the features presented above. For instance, an application software for children may not contain words and phrases at all because they cannot read. Hence, the feature of upper and lower case letters may not be considered. The flowchart of the Animo Math, which explains its features and talks about how it works, is designed as illustrated in Figure 1.

4.2 Role Playing and Interface Design

In this part, the principle of the game menus is briefly explained. If a new player wants to play the Animo Math, the player is required to create a user in order to log into the application. This helps us record players' information for the role-playing game. Additionally, the name of a current player, who has achieved the highest score, will be recorded at the end of each game. The screenshot for creating a new user is demonstrated in Figure 2. After this scene, eight Animo characters are illustrated immediately for the new user to choose. The screenshot for selecting the Animo characters is presented in Figure 3. The player is able to interact with the game via the selected Animo character. Once the user's name and Animo character are created, the game will be ready to play. The main menu of the game is at the bottom of the screen, as shown in Figure 4. The selected Animo cartoon will appear on the screen in bright colours to catch the attention of young players. It will dance with soft music.

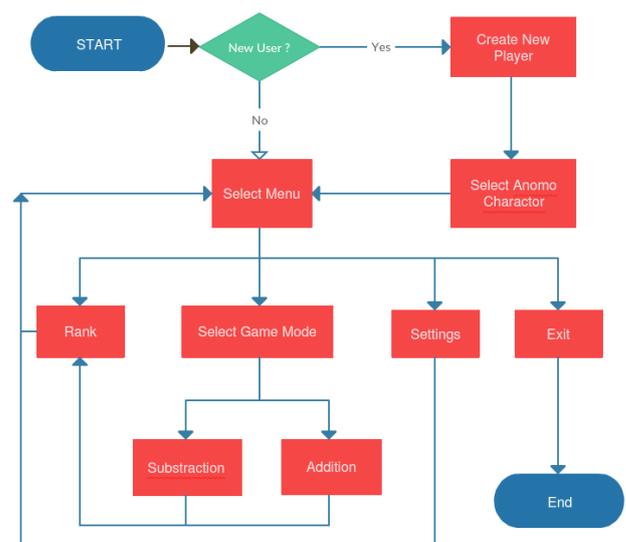


Figure 1. Animo Math flowchart



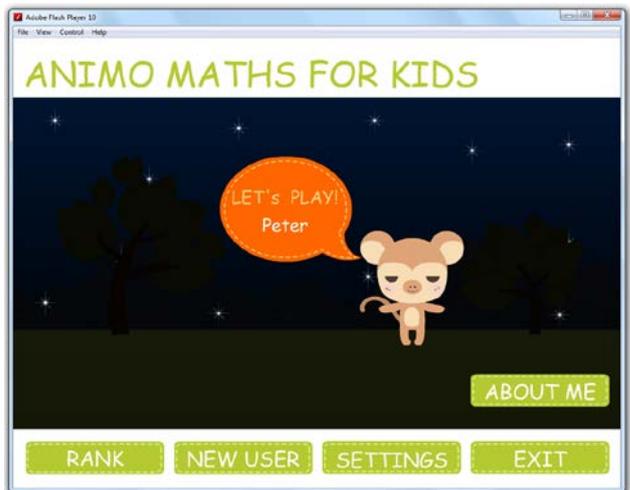
Figure 2. Screenshot for adding a new user.



(b) An Animo can work slowly in the evening (Tardy mode).



Figure 3. Screenshot for new user to choose an Animo character.



(c) An Animo will sleep during the night, and it is difficult to play for the current game (Sleepy mode).

Figure 4. Screenshot of the main menu



(a) An Animo is lively and ready for play during daytime (Active mode).

In order to keep on challenges in the game, the background of the screen will be automatically altered little by little if the player had made mathematics answer correctly lower than 50% for every three consecutive games. Figure 4 (a) illustrates daytime. It is called an 'Active mode', where the Animo cartoon is the most lively to play. In the case that the players have failed to answer several mathematics questions in the game, the screen alters slowly into the screen of the evening as presented in Figure 4(b). It is called a 'Tardy mode'. If more mistakes were made, the screen will get darker and darker. At that time, the Animo characters will sleep and be rarely interactive with the player. In this situation, the game is in a 'Sleepy mode'. An example of this screen is shown in Figure 4(c). Then, the game will take a few seconds to be in this tardy

mode. After that, the Animo cartoon of players will be able to play as an active mode by the system of the game. However, if the score of following game is greater than 50% of the total number of the questions, the game mode will be automatically turned to “Active mode”. The percentage of correct answer can be calculated by (1). As the answers to the current questions affect their Animo character, this encourages young players to participate in the game more carefully and cautiously. The Pseudocode for the Animo Math is demonstrated as follows.

$$\% \text{ of correct answer} = \frac{\text{Total no.of correct answers}}{\text{Total no.of questions}} * 100 \% \quad (1)$$

```

Pseudocode for Animo Math:
Main Procedure Animo_Math
Begin
  Set Count_Failure to zero.
  Set Max_Level to 6.
  If a player is new then
    Set initial value for the user.
    User_level is equal to 1.
    Game_mode is equal to “Active mode”.
  Else get the User_math_level and User_mode.
  Repeat
    Call Procedure Animo_play. /*Play the game*/
    If User_score is in the top 5 scorers then
      Add user in the top 5 scorers.
    If User_score is less than 50% of the total number of questions
      Count_Failure = Count_Failure +1.
    Else
      Set Count_Failure to zero.
      Set Game_mode is equal to “Active mode”.
    End if
    If Count_Failure is equal to three then
      If Game_mode is equal to “Active mode” then
        Set Game_mode to “Slow mode”.
      Else if Game_mode is equal to “Slow mode” then
        Set Game_mode to “Tardy mode”.
      Else
        Set Game_mode to “Sleepy mode”.
      Endif
    Endif
    If User_Score is higher than 85% of the total number of questions
      && User_level != Max_Level then
        User_level = User_level + 1
    Else if User_Score less than 50% of the total number of questions
      && User_level is greater than 1 then
        User_level = User_level - 1
    End if
  Until the user exits the game.
End.
    
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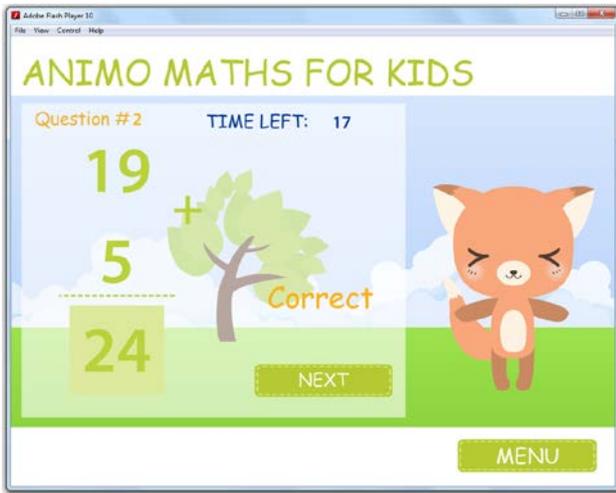
Figure 5. Pseudocode for Animo Math.

As presented in Figure 4, the player can start playing the game by clicking on “LET’s PLAY”. The following submenus, namely 1) Addition and 2) Subtraction, will be displayed in the middle of the screen. The screenshot is displayed in Figure 6. And, the example screenshot for “ADDITION” is presented in Figure 7. As mentioned above, the game is designed to support different children in terms of

matching their mathematics skills. For that reason, the game tries to match the math skills to suit each player so that the player can develop as much as possible. While playing, if users can complete the game with a good score, the following games will be more difficult. On the other hand, if the player can complete the game with a bad score, the following mathematics questions will be easier. The detail of this part is in the Pseudocode as presented in Figure 5. The current score of the player will be stored in the database of the system. The user is able to play the game several times as they want. For each game, there is no specific number of questions for each user to complete. They can answer as many as they can. In order to have more challenges, the player needs to complete as many questions as possible. But, there is no limit to the number of questions to complete. The application may pause to allow the children to think. As presented in Figure 7, the game has a countdown timer of 60 seconds. The user needs to type in the answer in the answer box. All mathematics questions will be randomly created by the system, which are not over two digits of numbers. However, it depends on the mathematics level that the player is playing. If the player has made a mistake and cannot find the correct answer, the player can check the answer anytime. If a correct answer is given, the Animo cartoon will be dancing with happiness. The example screenshot for providing a correct answer is illustrated in Figure 7 (a). Alternatively, if the player has given an incorrect answer, the Animo cartoon will be unhappy by showing sweat drops as presented in Figure 7(b). After that, the following questions will be shown respectively. Every time the user completes a game, the number of questions and the total number of correct answers will be displayed. The example screenshot for this part is presented in Figure 8.



Figure 6. A screenshot of the main menu



(a) An example of Animo actions when the correct answer is given.



(b) An example of Animo actions when the incorrect answer is given.

Figure 7. Example screenshots for providing answers

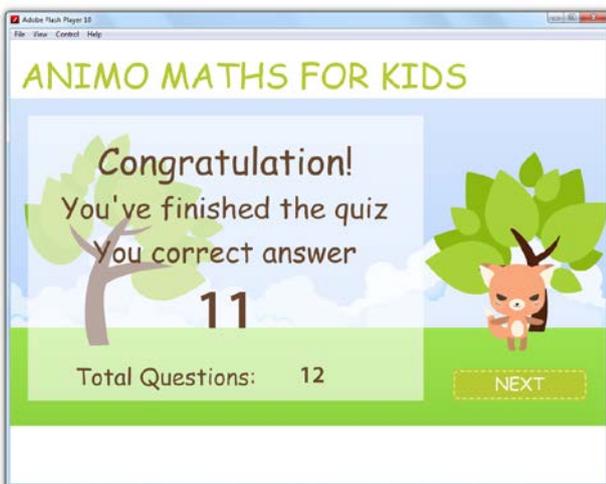


Figure 8. An example screenshot of the total score (% of correct answer = $\frac{11}{12} * 100\% = 91.67\%$).

At the end of each game, if the new score achieved by the current player is high enough, players' name will be added in to the top five scorers. Moreover, the top five of the highest scores are demonstrated after each game. The example screenshot for the highest score is presented in Figure 9. It is important to state that only one player can log into the game at a time. Nevertheless, it allows several players to play the game, since all players' information is kept in the database of the system. Moreover, the game allows users to change settings in the game such as sound effects, screen size, and the Animo cartoon. The screenshot for the Animo Math's setting is illustrated in Figure 10.



Figure 9. An example screenshot for the highest scores.



Figure 10. A screenshot for Animo Math's setting.

5. Evaluation of User Satisfaction

There are several things to consider when we are designing the role-playing game in mathematical learning. Additionally, user testing is important for our work. It has proven to be extremely helpful in the design for developing several software games [16]. To identify the existing usability flaws is to listen to what users say. It also helps identify program flaws that need to be fixed. Naturally, most gamers are concerned with the provision of an enjoyable experience for players. Nevertheless, for this paper, we are interested in what children learn while they are playing the game. Twenty parents of children agreed to let their children play the game. The children were playing while their parents supervised them. After the game-playing experience, all parents were willing to evaluate the quality of the game. A typical Likert scale is used as an important tool for survey research, such as Lee et al. . Hence, each question in this paper uses a five-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree). Figure 11 shows the overall results of what respondents thought about Animo Math in terms of enjoyment and the level of challenge for their children. As we can see, Animo Math has proved to be enjoyable yet challenging. Several parents agreed that Animo Math can be used as an education tool for children to learn basic mathematics especially for addition and subtraction. If children play this game several times, their mathematical skills will be definitely improved. Figure 12 represents the overall satisfaction of all respondents. One user stated, “It is good for the kids to learn basic Mathematics, and my child was having fun.” The other users reported that by applying a role playing game, the game becomes very attractive. Also, one respondent said that the system is okay, but that they would like to play this kind of game with their child on their phones. This parent suggested that the game should be supported on other devices rather than computers.

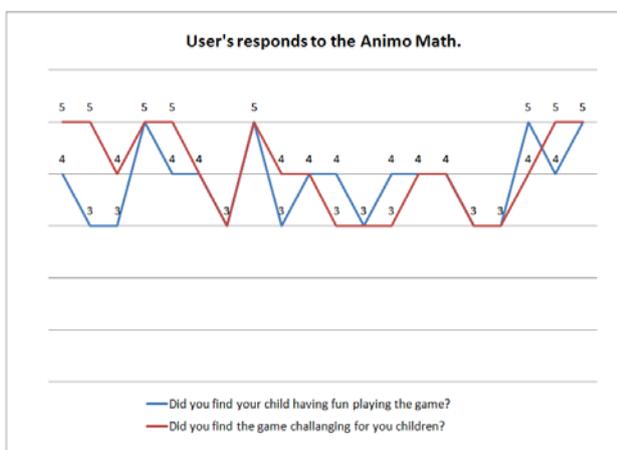


Figure 11. Users’ responses to Animo Math.

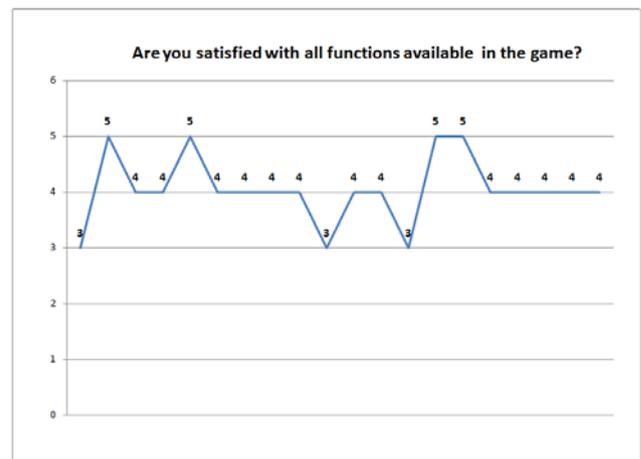


Figure 12. Overall satisfaction of the respondents regarding the functions available in the game.

6. Conclusion and Future Work

The main purpose of this paper is to develop educational games for mathematical learning. The role-playing game is adopted in order to motivate children to learn mathematics. This game is designed for children aged 5-7 years. Therefore, we aim to design the game in order to assist children to solve mathematics questions with enjoyment. Based on our survey, it has been proven that Animo Math can be used as an educational tool for learning since positive feedback has been obtained. Furthermore, most respondents prefer that their children play digital games if they explicitly help the children to learn while playing. Additionally, some parents have confirmed that they appreciate a computer-based learning game by which it provides a great learning experience for their children.

We hope this paper encourages more researchers and educators to develop more educational computer programs for children. Additionally, we expect that Animo Math will be utilised as an educational tool in mathematical learning not only for Thai children but also for others.

For future work, children's expectations of role-playing will be discussed. We also plan to upgrade the game for older children; therefore, the plot of the game-based learning needs to be more complicated. We will establish more tasks for each cartoon character and collaboratively create stories within the game. We also aim to develop the game for smartphones using the Android platforms and IOS.

Acknowledgements

The author thanks you, acknowledge Mr. Saksit Emarereerat, who devoted to develop the program to complete the entire process of the algorithm, including cartoon animations.

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