Design and Implementation of Educational Game to Improve Arithmetic Abilities for Children

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***Abstract*—Game is an entertainment application for user or children at this time. A game can deploy not only on the computers but also on mobile devices, especially in the Android operating system. But today, many games have an addictive system but has no educational system. The educational game is important for a user to get both education and entertainment. In this paper, a game is using a method to establish a level automatically and varied both in games and educational material attributes. Experiments suggest that the game received positive feedback on the user interface, system performance, and educational lesson. With this result, we conclude that the game is fun and easy to use for the children. With this game, the kids who have played can improve calculating speed level and improve accurately answer for an arithmetic lesson.**

Keywords— E-learning, Educational game, Dynamic game, User Interface, Mathematics education.

I. INTRODUCTION

Today, children love the game. According to the Federation of American Scientist, kids aged eight until eighteen spend on average 50 minutes per day to play digital games [1]. Other research, children aged 9-16 spend 88 minutes per day playing computer and the second most common activity is playing games on the computer [2].

Game developers realized that the most important entertainment value of the game is an instructional content during gameplay [3]. Serious Game appeared because of that reason and it has more entertainment content such as role-playing, story-based environment to teach, train, and change knowledge, behavior, and attitudes. The serious game also has a purpose for government, military, corporate, education, and healthcare [4].

A. Educational computer games

Computer games are promising educational tools at this time [5]. Motivational aspect is the most common benefit of computer games for education [4]. A game is a tool for learning because it can provide feedback from players. Players usually see the effect of their action in the game [6]. Moreover, games allow players to try, make mistakes and try again to get experience without being ashamed [7]. This risk-free environment of computer games causes many players to have high motivation to explore and experiment when playing games [8]. Games also can offer and provide students opportunities for experiential learning and enabling them to discover new strategies and rules [5].

Because of previous research, computer games are more and more becoming part of primary school education [9]. In addition, the comparison between educational computer games and conventional instruction proves that educational games have a positive effect on student [10]. However, the result of their research did not find a significant effect. Furthermore, other review studies indicated that there is still insufficient experimental evidence in the school practice for the effectiveness of educational computer games, and needed a large scale in class longitudinal studies [11]. Also some authors of review argued that studies on the effect of games and other educational software quite often lack and suffer from methodology such as not applying random assignment to condition [12], not using a control group [13], not accounting for nested data structure [14], and just using a small sample [15].

According to some research, mathematics education is often using computer games and other educational software [16]. For the domain of mathematics or arithmetic, evidence for the effect of educational games is still insufficient yet [17]. Also, the analysis of research indicated that ICT in mathematics education provides positively affect learning outcomes, but analyses in games were not taken as a separate category [18].

According to Marjoke, he wants to get and gain evidence about the effectiveness of deploying computer games in mathematics education. His research focuses on mini-games in the domain of calculative reasoning such as addition, subtraction, multiplication, and division in elementary school, and his research indicated that games can improve mathematics education for students [19].

B. Our Approach

This research continues and compares our previous research about the educational game in text mining [20]. We build a game education about calculation mathematic (addition, subtraction, multiplication, and division) like previous research. According to our previous research, game desktop and mobile is trend entertainment device at this time [21] and game design for artificial intelligence in our previous research also provide positive feedback from players [22]. But this game will deploy in desktop and android platform. The game implements adaptive, automatic, and variety level to make more interesting.

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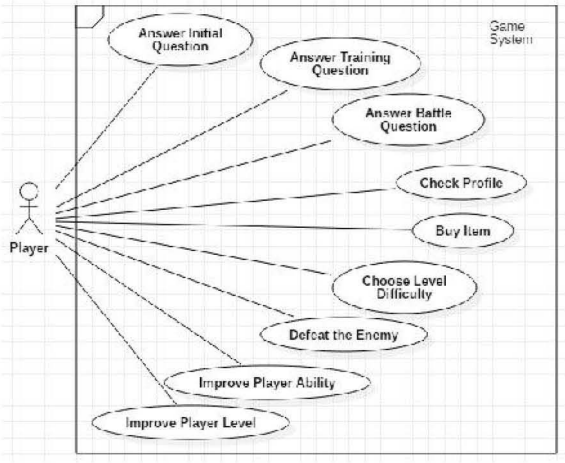


Figure 1. Use case diagram in system game

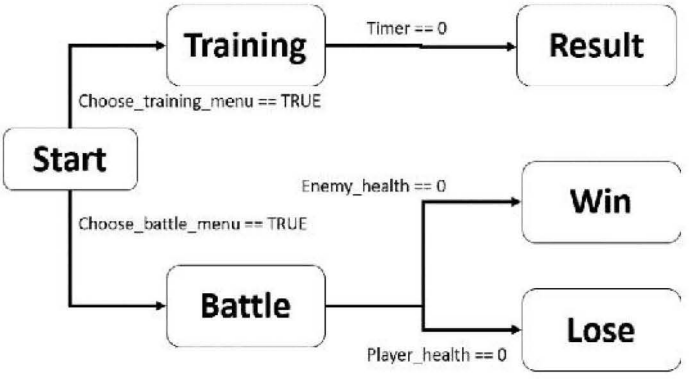


Figure 2. The main menu flow for training and battle

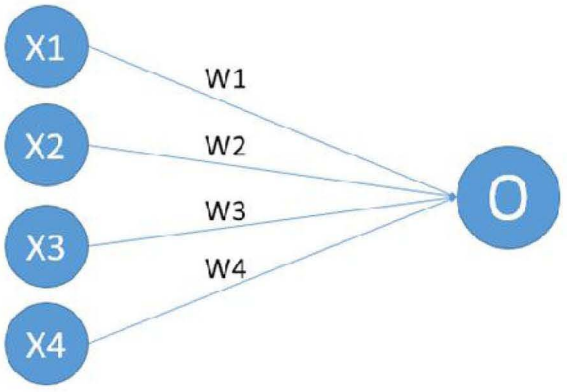


Figure 3. Concept calculation of level difficulty

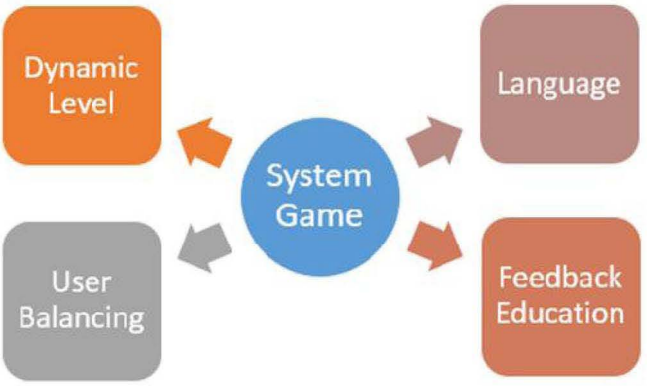


Figure 4. The main feature in the game

This game not pure education game but this game will merge form RPG and education genre. We just investigate about feedback from the user how good or bad our game education for the user. We just focus on three main questions. There are the user interface, system performance, and education lesson

II. METHOD

A. Design use case

In this step, the game must have a use case for minimum design. They are consist of functional requirements and non - functional. Based on these, the game has nine use case. They are Answer the Initial Questions, Answer the Training Question, Answer the Battle Question, Check Profile, Buy Item, Choose Level Difficulty, Defeat the Enemy, Improve Player Ability, and Improve Player Level. Actually, the game has a lot of use case but the other use case not be written because they are just minor use case. Use case for users of the system who play the game is listed in Figure 1.

B. Design Data

The design of the data in the game is divided into two data. They are data educational and data system game. Data educational is available for all levels in the game. The data educational for lesson get from mathematics lesson elementary school from grade one until grade six which adjusting the curriculum in Indonesia. The design of educational data is only used at the beginning of the interface gameplay before the core game. Data educational which is used in the core game is just a number and math operator.

Data system game get from random value and the initial value of the number. The initial value set by the game developer and the random value set by a system which is processed and dependent from an initial value and level design. Data system game is used in all event or menus. Both data educational or data system game is very important for this game to make user can get more lesson and enjoyable education.

C. Design flow menus

The game also must have gameplay or rule of the game for making enjoyable. The outline of gameplay in this game is only divided into two flow game. They are located in the training menu and battle menu. Training menu is used to practice game character and the battle menu is used to fighting game characters. Flow for the training menu and battle menu are shown in Figure 2. Training menu and the battle menu is the gameplay in this game. Both training and battle menu has feedback result for the user. This feedback can make user introspection about his action. In the training menu, the game is over when the time is null or the question is empty. And in battle menu, the game is over if the player or the enemy is dead.

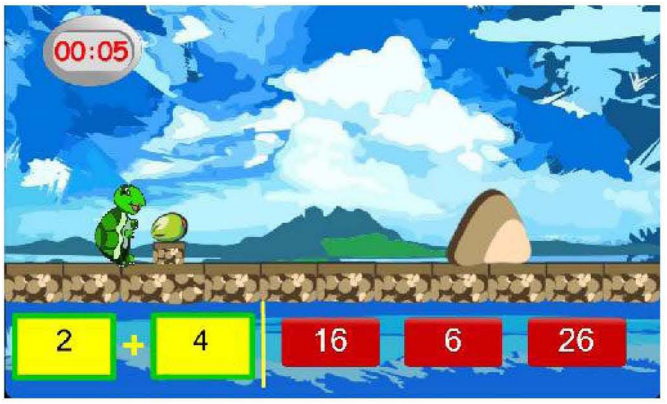


Figure 5. An interface of training menu in game

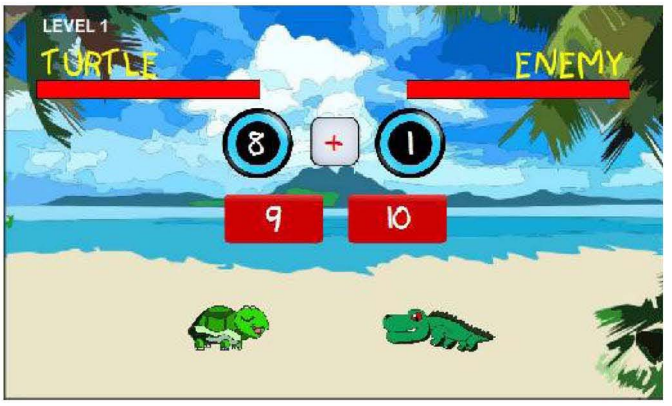


Figure 6. An interface of the battle menu in game

Table 1. List of the question for user interface and system performance

Assessment	Question
User Interface	Ease using Games
	Complete menu
	appearance
	User experience
	Related theme
	Interest interface
System performance	Performance speed
	Level variety
	Accurate data output
	Smoothness of animation
	Related animation with system
	Interaction system

Table 2. List of the question for the educational lesson

Assessment	Question
Educational Lesson	Education value
	The effect of improving speed calculation
	The effect of improving the right answer
	The effect of improving knowledge
	The effect of improving enjoyable to study
	suitable user target
	Enjoyable education
	Appropriate education with a level in the game

D. Level game

Each level has a static weight level where the value of the weight ranges from one percent to one hundred percent which is indicated of difficulty. Having raised the level of education lesson are also raised. Each level also has a level of enemies that are built dynamically and randomly fit the design of the data. Having raised the level of education lesson are also raised.

The generation of an educational lesson is dynamic that build randomly assigned a number value which corresponding to the level of the existing rules. The rule is level one has 1% difficulty level and level 100 has 100% difficulty level. Dynamic level is used and implemented in this game to make variety difficulty level. The concept of dynamic generation level is like linear calculation. Every component of difficulty has a percentage of weight. All of the input difficulty will multiplicity with its weight and produce the output of level difficulty. The concept of this calculation is shown in figure 3.

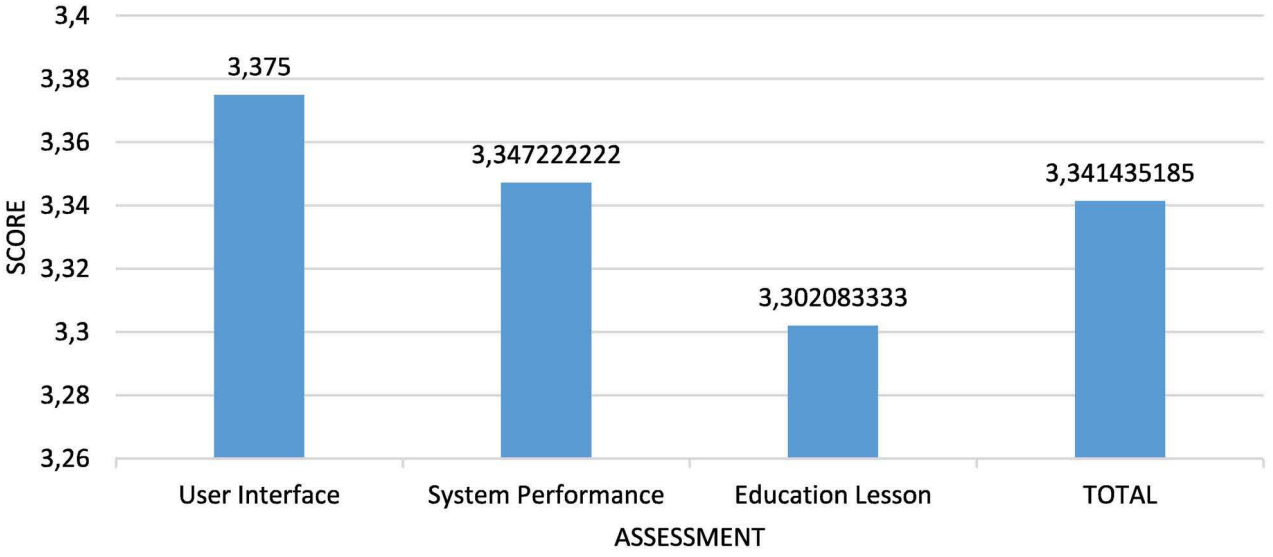
E. Game Feature

In this game, we build a lot of features such as dynamic level, user balancing, language, and feedback education which is shown in figure 4. Dynamic level is a level which is built by a dynamic generation method. This dynamic method consists of two-step namely automatic and varied level. Automatically means the development of the level is built by the program and not manually. Nevertheless, the variety means that the development of one level and other levels have different components.

The second feature is user balancing which implements the adaptive method. This adaptive method is built by paying attention to the player's ability as a reference for the next level. The example is a player which has a bad score of mathematics education will get level one. But the player which has good grade will go to level five. This game also has a language feature which is consists of Indonesia and English. Furthermore, every level such training and battle have feedback from the result of the game. Every feature in this game is to make the game more interesting.

F. Participant

The user of this game is not limited that means the user can be children from elementary school, junior high school, senior high school, and adult. Every user who has played this game was giving feedback to us to make improve our game. But the related participant for this research is children who still study in elementary school in Indonesia. The children ages are from 7 years old until 13 years old. The number of users is thirteen children who have played this game. The related participant just gives feedback about the user interface, system performance, and educational lesson in this game.



III. Result and Discussion

Before we publish this game on the internet, we tested a system game by our self in a conditional environment. The environment consists of a smartphone platform Android, a desktop platform with an executable extension, and website platform HTML using adobe flash player. We tested this game for the desktop platform in the personal computer. The result of system performance assessment in our environment was no lags or good performance. But also this game not supported google service. We publish our game into a website which it can access in http://www.turtletrainer.blogspot.com for website platform. The interface of this game is shown in figure 5 and figure 6.

We publish this game on the internet and make a questionnaire about the related assessment of this research. The thirteen related participants give feedback and give a score about three assessment. The participant can give a value score from one until four. One is a bad game. Two is the average game. Three is a good game. And four is a very good game. The questionnaire topics are shown in table 1 and table 2. After we publish for several days, the average the result is shown in figure 7. This score indicated that the education game is a good game is the user interface, performance, and education. But this game must be converted into other game engines because this game is still using Adobe Professional Flash with action script 3.0. Because this year, flash is obsolete and abandoned by the user. Furthermore, in further research, we will develop this game using a popular game engine like Unity. Regardless of that truth, if flash compared with other game engines, then flash is still won and better than others in animation projects.

IV. Conclusion

From the evaluation, we can conclude that this game is suitable for the user especially for children who still study in elementary school. The total score of the assessment indicates that the score is more than 3.2 and we can call it 80% in percentage. In Figure 7, we also can conclude that User interface, system performance, and education lesson have more than 3.3. This value represented that this game is balanced and easy to use. This score is the first step to make this game enjoyable. We know this game still has a lot of lack and must improve to make a better game. So in future research, we will improve and develop this game using more related data education in math. Then we will add character and object interface to increase enjoyable for the user. Also, we will develop this game by using a popular game engine like Unity or game maker. Furthermore, we will analyze the result of many education game kinds of research.

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