The effect of game-based learning toward conceptual understanding

W D P Putra¹* and W Setyaningrum²

¹Pendidikan Matematika, Program Pascasarjana, Universitas Negeri Yogyakarta, Jl. Kolombo No.1, Karangmalang, Depok, Sleman, Yogyakarta 55281, Indonesia
²Departemen Matematika, Fakultas Matematika dan Ilmu Pengetahuan Alam, Universitas Negeri Yogyakarta, Jl. Kolombo No.1, Karangmalang, Depok, Sleman, Yogyakarta 55281, Indonesia

*wandennyp@gmail.com

Abstract. The aim of this study is to examine the effect of game based learning toward conceptual understanding in learning mathematics. This study was an experimental research with design non-equivalent group pre-test post-test which consisted two classes. This research was conducted in one of the junior high school in Yogyakarta Indonesia. The respondents in this research were 58 students with low proficiency. The experiment class was taught using game-based learning while the control class was taught in conventional ways without game. The effectiveness of game-based learning was analysed using Mann-Whitney test. The result of data analysis showed that (1) game-based learning was not effective viewed from conceptual understanding (2) there was difference in terms of conceptual understanding between students who taught using game-based learning and those who taught in conventional method. Game-based learning can be an effective learning method if in practice pay attention to several factors that may influence it.

1. Introduction
Mathematics is used in many aspects of life. It is one of important subject to learn at school because it is one of requirement or basic science to learn and explore other sciences such as physics, chemistry, biology, architecture, engineering and others. Another benefit of learning mathematics is it could train students to think systematically and coherently thus it helps students to organize everything. The importance of mathematics and many benefits of learning mathematics does not make mathematics much favored by students. Many students think that mathematics is the most difficult and boring subject. Based on data of Program for International Students Assessment (PISA) [1], Indonesia ranks 63rd out of 70 countries with a mathematics’ average score 386 compared to 490, which is the global mathematics average score. So it takes a learning method that makes mathematics easy to understand and fun to learn.

Game-Based Learning (GBL) method can be one solution to make learning more fun. Sousa and Rocha [2] states that game-based learning is a concept that is structured around a learning process that uses as the primary pedagogical tool a specific game which helps to arise and develop skills. The results of research conducted by Papastergiou [3], digital game-based learning can promote curricular knowledge and student motivation in core academic subjects. Digital games provide animated graphics and audio effects as well as immersive stimulation [4]. With interesting visuals, animations, and games
can increase student motivation. With the motivation of the students will be more spirit in learning mathematics so that learning outcomes will increase. In line with Cheng and Su [5] states the educational game makes the learner become the center of learning, which allows the learning process to be easier, more interesting, more effective. Furthermore, educational technology makes teaching and learning activities enjoyable [6]. GBL used in this study is based on smartphone applications. Smartphone is used as a learning media because based on data from Kominfo, smartphone users at the junior high school level more than 77% [7]. The application used in this study named "Circle". "Circle" is an application on smartphones developed by researchers. "Circle" has been tested valid, practical and effective. The validity of this product is based on the results of the assessment of media and material experts. The practicality of the product is assessed based on the results of the student's response and the teacher's response. Meanwhile the effectiveness of this product is determined based on the result of students’ interest in learning mathematics after using this product. This application contains competencies, materials, and games. The "Circle" is a simple game of arcade game type. Students just pass through some obstacles on the game and there are some questions they have to answer. The questions consists of four types, namely: multiple choice, true-false, select the picture, and short answer. Materials and questions in “Circle” game are developed based on the current curriculum implemented in Indonesia.

![Figure 1. Visualization of menu.](image1)

![Figure 2. Example question type “select the picture”.](image2)

![Figure 3. Example question type “short answer”.](image3)

![Figure 4. Example question type “multiple choice”.](image4)

The purpose of this research is to examine the effectiveness of GBL method by using educational game called "Circle" in terms of students' conceptual understanding. Students' conceptual understanding is important to investigated because it is one of the four dimensions of knowledge (factual, conceptual, procedural, and metacognitive) used in Indonesia [8]. Meanwhile, the limitation of this research is only using educational game developed by researchers, not using educational games from various other developers.

2. Experimental method
This research was quantitative research with quasi experimental method. Design experiment in this research referred to non-equivalent control group design. This research was conducted in one of junior
high schools in Yogyakarta. This school ranked 13th out of 17 SMP Negeri in Yogyakarta city based on the average value of national exam in 2017. The classroom grouping at the school was based on the average value of student’s national exam in primary school. This research used an experimental class and a control class. The two classes which used in this study were classes with low categories in terms of students' ability. Each class was taken by respondents of 29 students, so the number of respondents in this study was 58 students.

This research procedure began with the pre-test in both classes. It aims to know prior knowledge of student in conceptual understanding. Further treatment was given to the experimental class was applied the GBL method using educational games. While in the control class was gave conventional methods without using educational games. Lessons were conducted for five meetings. The sixth meeting held a posttest in both classes to assess students' conceptual understanding. Instrument in this research was conceptual understanding test of student with number of 20 multiple choice questions. The next step was data analysis to test the research hypothesis. Hypothesis in this research is game-based learning effective viewed from student’s mathematical conceptual understanding.

The GBL criterion is said to be effective if (1) there is a significant difference between the experimental class and the control class after treatment; (2) the average experiment class is higher than the control class; (3) the experiment class average is greater than minimum school completion criteria (75).

3. Result and discussion

According to the pre-test results, data gathered from the experimental class is normally distributed while data from the control class is not normally distributed. Thus, data analysis in this study uses Mann-Whitney U.

![Table 1](https://via.placeholder.com/150)

| Output | Pre-Test (Sig.) | Post-Test (Sig.) |
|--------|-----------------|-----------------|
|        | 0.831           | 0.000           |

The significance value obtained from the Mann-Whitney U analysis is 0.831. As the significance value (0.831) is more than 0.05, this means that there is no significant difference between the experimental class and the control class. Therefore, it can be concluded that the experimental class and the control class comes are equivalent.

After five meetings, experiment class and control class were given post-tests about conceptual understanding. The data analysis shows that the significance value is 0.000 which is less than 0.05. This means that there is a significant difference between the experimental class and the control class after the treatment is given.

In order to explore the differences, the data of conceptual understanding in experiment class and control class were categorized based on the figure below.

![Figure 5](https://via.placeholder.com/150)

**Figure 5.** The value of students’ conceptual understanding in both classes by category: Very Low (0 – 20), Low (21 – 40), Medium (41 – 60), High (61 – 80), and Very High (81 – 100).
Result in experiment class showed $M = 50.52$ and $SD = 9.291$ while result in control class $M = 35.17$ and $SD = 11.763$. It can be seen from Figure 5 that more than half of the students’ (69%) in the experimental class are in medium category while in control class, most students are in low category (66%). This implies that the students in the experimental class have better conceptual understanding than their counterpart in the control class.

Although there are significant differences and the average score of conceptual understanding of the experiment class is higher than those of control class, the average value of the experimental class does not exceed 75 that $H_0$ is accepted. This means that the method of game based learning is not effective in regards to students’ conceptual understanding.

There are several possible explanations why game-based learning does not effective to support students’ conceptual understanding. Motivating students to learn is not simply putting entertainment into learning or assignment as the students might only play the game instead of learn the material or concepts provided [9]. Moreover, students are just trying to finish the game quickly. They just need the right answers to get to the next level regardless of how the process or way of solving the problem. Therefore, students finish the game but do not get much knowledge about the material they are learning. Woolridge suggests that designing exercise should be good and in line with the learning objectives so as to create a useful active learning experience [10].

In addition, these types of games also affect their interest in learning. Based on research done by Khenissi [11], learning styles have a relationship to the type of games. Students in one class have different learning styles. The "circle" game might only facilitate students on certain learning styles and some students who do not like this type of game might unfacilitated. The games used in GBL should vary, in order to facilitate all students to learn according to their learning styles. In developing the game also needs to considered the trend that is being favored by students at that time. But it is not easy, because video games are constantly being upgraded [12].

In the application and development of educational games, there are many factors to be considered. Olson and Clough [13] argue that technology often diminishes the need to attend seriously priority knowledge, to use metacognitive strategies, question prior ideas, generate examples, compare alternative solutions, grapple with experiences, make sense of these new experiences, make new connections, and analyze what prior connections make sense. Meanwhile, Prensky [14] also formulated six structural factors which make a game a game: (1) Rules, what differentiate games from other kinds of play; (2) Goals or Objectives; (3) Outcomes and feedback, how you measure your progress against the goals; (4) Conflict, Competition, Challenge, and Opposition; (5) Interaction player with the computer and other people; (6) Representation. Veenstra, van Geert, and van der Meulen also suggested [15], educational games should pay attention individually, age and sociocultural appropriate characteristics. Regarding to these structural factors, the Circle might need to be improved especially in terms of conflict, competition, challenge and opposition so that the students could be motivated to play as well as learn more.

4. Conclusion

Based on the results of data analysis, there are significant differences between the classes that use the GBL method with a class that does not use the GBL. The average value of a class using the GBL method also shows higher value than class that does not use GBL. Nevertheless, GBL is not effective in terms of students’ conceptual understanding because average grade does not reach the minimum school completion criteria. The GBL method could be combined with other methods so that it could be effective against students’ conceptual understanding. In addition, when developing and implementing game, there is a need to consider several factors that can influence the effectiveness of the game so that the goal of learning to make math is easy to understand and fun to learn can be achieved.

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