Guided Game Based Learning to Motivate Students in Study Natural Science Subject

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Abstract. According to observations in one of junior high schools (SMP) in Klaten, Indonesia, the most difficult subjects that perceived by students is natural science, more specifically in topic of rectilinear motion. Therefore, they are less motivated to study, whereas the subject is a basic foundation to continue the next discussions. To tackle the problem, Guided Game Based Learning (GGBL) is proposed, a method to teach students by games and guided by teacher or assistant in the teaching and learning process. This research aims to apply GGBL which involved 26 students. The gameplay was designed based on the existing Learning Implementation Programs (LIP). Data obtained from observations, pretest, post-test and in-depth interviews and analysed by descriptive statistical. Result shows that before and after applied GGBL method have escalation mean score, namely 2.38 point. Non-parametric test used to explore the effect of before and after implementing GGBL, because the distribution of data is not normal. Calculations perform that Z-score is -5.243 and p-value is less than 0.05 with significance level 0.05 (p<0.05). Hence, pretest and post-test have a meaningful difference, which means that GGBL has an impact to the teaching and learning process. The questionnaire also obtained that 87.9% of the students were motivated to study through the game, so that the GGBL method can be implemented to wider classes.

1. Introduction
Rectilinear motion or straight-line motion is one of topics taught in natural science lesson of 8th grade of junior high school (SMP) in Indonesia [1]. The lesson discusses about movement of particle or body along straight line from one point to another. This topic is cornerstone to understand other types of rectilinear motion for further, namely uniform rectilinear motion and accelerated uniform motion. This concept is applied in the real life, for example to compute velocity of vehicle or to estimate travel time on Global Positioning System of digital map. Therefore, comprehend this topic will help pupils to study the next advance topics of natural science.

Based on the observations and interviews in SMP Muhammadiyah 1 Klaten, Indonesia, found that some students less motivated to study natural science subject and lean to perceive that it is difficult. Conventional learning method is one of the causes, since just teacher who active to teach while students are more passive. The students were just listening when the teacher convey material subjects. Therefore,
it made the teacher to be the only source of learning, so that if an error occurred on delivering subject matter, students cannot evaluate it correctly. Within certain time, the students will feel less motivated, since they are digital native generation [2] who have active characteristics. They are well versed in using technology for daily activities [3], so that they prefer to find out material contents by themselves on the digital world [4] than just pay attention to the teacher. Even more, they also tend to spend their time for playing digital game [5] prefer than pay studying. Hence, active and interactive learning method is needed to tackle the problems, for instance by combining learning materials into the game.

Game that contain educational content or educational games have potential benefit to motivate students to learn, because the game provides an enjoyable learning and experiences [6]. In addition, the game may help students to train difficult material subjects through firsthand experiencing situations or through a role-play that provided on the game. One of researches on educational game to help and facilitate teacher in delivering subject matters was done in Bandung, Indonesia, to support students in mathematics studies [7], but no guidance from teacher in the implementation. Educational game also can be used to improve preschoolers’ knowledge for preventing diarrhea disease [8], so that it is possible to design game for teaching and learning process in natural science as well. The method of using games to support teaching and learning is commonly referred as Game Based Learning (GBL) [9].

Research on the GBL stated that the model is effective to promote pupils’ learning achievement, self-efficacy, and encouragement [10]. The Principles of GBL [9] include:

a. Gaming is actually motivating because a player usually plays voluntarily,

b. Learning through enjoyment and “fun” media,

c. Authenticity or learning naturally,

d. Self-reliance and autonomy that encourages independently inquiry and exploration, and

e. Experiential learning by doing.

Despite the fact that GBL is being broadly utilized in a variety of settings and domains, this method still has a lack, no guidance from teacher. Without guidance, students potentially to do activities outside of learning goals that makes learning outcomes are difficult to be reached. Because, actually game just tool that used to assist, while the teacher still has important role in teaching and learning process. Hence, Guided Game Based Learning (GGBL) is proposed, where games that designed appropriate to Learning Implementation Plan (LIP) are used as tools and the process is guided by the teacher or assistant.

Rest on the above argumentation, the main objectives of this study were: (1) to develop and implement an educational game that designed based on LIP for learning media to support GGBL model, and (2) to assess the effect of GGBL by pretest and posttest result of students before and after playing the game. Material subjects of the game limited to rectilinear motion in Natural Science of SMP in Indonesia.

2. Methodology
The research was conducted at SMK Muhammadiyah 1 Klaten, Indonesia, which involved 26 students as research subjects. The research objects were test results before and after applied guided GBL method through pre-test and post-test. Students’ motivation also became object of this research which was discovered by questionnaire, interviews and observations. The methodology is divided into several steps, such as literature review, data collection, game design, testing to students, and data analysis to know the effect before and after implemented guided GBL.

2.1. Literature Review
Literature review was done by searching and collecting article references from various sources, both from journals, proceedings and related articles from any resources. This step aims to find out similar studies that have been done previously, so that it makes easier to formulate the research problems. Keywords used to collect references are rectilinear motion, game-based learning, educational games, learning media and coincident topics.
2.2. Data Collection
Collection of preliminary data was done through observations and interviews about the real conditions at the research site which involved students and teachers. Students observations were useful to figure out their activities and behavior during the teaching and learning process. Meanwhile, interviews were used to know how the teachers delivering subject materials.

To help the teacher in teaching process, LIP is needed in order to suit with the basic competency and competency standards. Table 1 shows a part of LIP that discuss a chapter about motion, where understanding rectilinear motion is one of basic competencies that will be achieved. Experimental data obtained from pretest and posttest of students before and after playing games. The data will be analyzed to acquire the result of research to answer the research problems.

Table 1. Learning implementation plan on chapter of motion.

| No. | Basic competencies                                                                 | Competence achievement indicators                                                                 |
|-----|------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------|
| 1.  | Understanding rectilinear motion and influence of force on motion based on Newton's Law, as well as its application to the creature and object motion in the world. | 1.1. Explain the motion types of plants based on their causes.  
1.2. Analyzing example of plant's motion based on the causes and stimuli types that received or parts of plants that respond to stimuli. |
| 2.  | Investigating to the motion, creature's motion, and experiments about the influence of force on motion. | 2.1. Analyzing animal motion tools based on their suitability for the environment.  
2.2. Explain the animal's muscular system in accordance with the pattern of motion carried out.  
2.3. Calculate the car's velocity using rectilinear motion formula. |

The table 1 describes several basic competencies and its achievement indicators which is should be attained students on the chapter of motion. Furthermore, this LIP will be used for foundation in designing goal of the game, like mostly games in general which is having mission to be accomplished. The LIP is very useful for references in designing gameplay, so that the game will be stay on the right track of learning outcomes.

2.3. Game Design
Refer to the existing LIP in the table 1, the first competence achievement indicators (CAI) is students should be able to explain about motion types of plant based on the causes and stimuli. Another CAI, students should be able to calculate the velocity of object that move on the straight line. Visual simulation of movements will be very useful to help students in understanding the topics. Appropriate scenario for that competencies shown on the Table 2.

Table 2. Scenario game design.

| Basic competence                                                | Scenario                                                                                           | Visual display                                                                                     |
|----------------------------------------------------------------|---------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------|
| 1. Understanding rectilinear motion and influence of force.    | 1.1. Player character move from one point to another in the next straight line in the certain time. | 1.1. Game screen displays information about taken distance and the time needed.                     |
|                                                               | 1.2. Distance value and time spent visualized by character movement.                               | 1.2. Formula to calculate velocity displayed on the game screen to help student understanding.      |

To motivate students, game arena and environment were made with dominant bright green colors, because generally children love the striking color [11]. To figure out business process and sequences of main system on the game, activity diagram was created as shown at figure 1.
Described on the activity diagram of main gameplay on figure 1, when user or player push the play button then system displays the game arena and the environment which include a character player. To start the game, player must push the arrow button of keyboard on computer or tap the screen on the smartphone. Afterward, character player moves ahead to another point of straight line. Along the way there are obstacles that must be avoided toward the longest path. Game will finish when the player cannot keep away from the obstacles, here the students train to concentrate. At the end of the game, students will see the formula of rectilinear motion, so they can learn to get the best result on the next game session.

2.4. Data Analysis
Research data were obtained from pretest and posttest questions, where the questions made were referring to the existing LIP. Questionnaire used to discover their motivation on guided GBL method. Then, the data analyzed using statistical analysis to find out the normality of data distribution to decide the next procedures that will be used. The data analysis is used to conclude the result of the research activities.

3. Results and Discussion
The educational game in this research was developed by Construct 2, a software for making 2-dimensional (2D) games based on Hypertext Markup Language version 5 (HTML5) programming which allows non-programmers to make a game with no coding required [12]. The game was divided into several scenes, include main menu level, settings, gameplay, reward, and exercise test. The game also can be distributed to cross platform, such as web page, personal computer (PC), and smartphones such as Android or iOS. In the game, the player character illustrated by a rabbit that should move from starting point to the longest distance. The player should avoid obstacles by jumping and run to get the best score.

Based on the existing LIP on the table 1, scenario on the table 2 and activity diagram in the figure 1, the game display that has been developed shown in figure 2. Before playing, a player will be given instructions on the screen so that makes easier for the teacher or assistant as instructor or even player to play the game. To start the game, player should push or tap on any places of device in the screen. The player also has option to back or continue to play the game or back to main menu. Time spent and mileage shown on the left and right corner of the screen. To control character, the player may use arrow button on the PC keyboard or tap on the smartphone.

Figure 1. Activity diagram of main gameplay.
Figure 2. Display of main gameplay.

Figure 3. Formula and result of velocity game.

Final result of time spent and mileage will be shown when the game ends. Material summary and formula will be displayed in the last scene, shown in figure 3. Therefore, students may learn the topic and formula that taught appropriate to the basic competence, for instance about how to calculate velocity of rectilinear motion. The formula and result shown with the big size and highlight on the screen, so that makes easier to remember. The player has option to play again, back to main menu, or study material topics.

The game was tested at 26 students in SMP Muhammadiyah 1 Klaten, Indonesia, they have to fulfill pretest questions beforehand, to figure out the initial ability of students. 10 pretest questions were given to them, and they should finish in less then 20 minutes. After break for some minutes, the students were shown and explained about how to use the game and important information of the game, for example learning outcome goals, as shown in figure 4. Then, students allowed to play the game for some time guided by the teacher or assistant as shown in figure 5. Although they play by themselves, they should be kept on guided in order to stay on the track of LIP. The guidance from the teacher or assistant while playing the game is important to gain the achievement competencies as expected in teaching and learning process. The teacher also responsible to motivate students to finish the game tasks to achieve the highest score. Here, the teachers have a big role to guide and establish passion and self-efficacy of the students through challenges in the game.

Figure 4. Assistant explains to the students.

Figure 5. Student plays the game.

Thereafter, the students should be completing posttest questions with the same tasks and time limit like the pretest. The posttest was used to discover how far the variance of before and after implemented the GGBL model. Figure 6 shows pretest and posttest score that acquired from the 26 students who accomplished 10 questions in time limit of 20 minutes which the range score is 0-10. Two students have no improvement score, namely student S9 and S13, three students get the highest score enhancement,
they were student S3, S4, and S12, who achieve 4 escalation score. Only one student who reach the best score of 10, namely student S2 who get climb with 3 point.

![Figure 6. Pretest and posttest score of the students.](image)

Statistical data that obtained from pretest and posttest after the GGBL could be summarized in table 3. The mean score of pretest and posttest are 5.85 and 8.23 respectively, means that escalation score is 2.38 point. Standard deviation and variance of posttest have a higher score, means that level of diversity and deviation from the mean value are higher after applied the GGBL method. The perfect score of 10 also can be achieved by one of the students, but the lowest score still has the same before and after implemented the GGBL method.

|                  | Pretest | Posttest |
|------------------|---------|----------|
| Mean score       | 5.85    | 8.23     |
| Standard deviation| 0.78   | 1.27     |
| Variance         | 0.62    | 1.62     |
| Median           | 6       |          |
| Highest score    | 7       | 10       |
| Lowest score     | 4       | 4        |
| N sample         | 26      | 26       |

Table 3. Statistical data of pretest and posttest.

Normality test was used to explore the distribution of data whether normal or the opposite. Test result that performed through Shapiro Wilk normality test [13] is shown in table 4. Both p-value of pretest and posttest are less than 0.01 (p < 0.01), means that the data distribution is not normal and the null hypothesis is rejected. In other words, the difference between the data sample and the normal distribution is big enough to be significant statistically.

|                  | Pretest   | Posttest  |
|------------------|-----------|-----------|
| w                | 0.857207  | 0.760692  |
| p-value          | 0.001969  | 0.000041  |
| Normality distribution | Not normal | Not normal |

Table 4. Normality distribution test of data.
Since the data distribution is not normal, so that to analyze the different effect of before and after applying GGBL is using non-parametric test. The method used was Mann-Whitney U, which the test result shown in Table 5. Obtained that Z-score is -5.243, and p-value is less than 0.05 with significance level 0.05 (p<0.05). It means that pretest and posttest have a meaningful difference, so that the alternative hypothesis (H1) is accepted.

Table 5. Statistic non-parametric test result.

| Combined result          |
|--------------------------|
| Sum of ranks             | 1378          |
| Mean of ranks            | 26.5          |
| Expected U-value         | 338           |
| Z-score                  | -5.243        |
| p-value (two-tailed)     | p<0.05        |

The table 5 shows that the GGBL method has an effect to the result of teaching and learning process of students. At the end of the GGBL activities implementation, the students had to answer a questionnaire about how they motivated or not with the GGBL method. Result showed that 87.9% of the students stated that they were motivated to do again in the future. They also interested in playing game that has been designed in this research, so that they can learn with playing at the same time.

4. Conclusion

Based on the result and above discussions, it can be concluded that the Guided Game Based Learning (GGBL) is an effective method and can be used for an alternative way to motivate students in teaching and learning process. The teachers or assistants have a big role to guide and to establish passion and self-efficacy of the students through the challenges of the game. The game designed should based on the existing Learning Implementation Programs (LIP) to keep on the track of teaching and learning process.

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