Research Article

Effects of Game-Based Learning Management on Learning Achievement in Mathemathics of Geometric Shape and Volume of Rectangular Shape for 6th Grade Students of Srinakharinwirot University Prasarnmit Demonstration School (Elementary)

Donsak Tsailexthim[1*] and Chalothorn Boonthima[2]

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ABSTRACT

The purpose of this research was to create and determine the efficiency of game-based learning lesson plan on mathematics learning achievement of geometric shape and volume of rectangular shape, to compare learning achievement before and after game-based learning management, and to study satisfaction towards game-based learning management. The samples of the study were 60 students of 6th grade at Srinakharinwirot University Prasarnmit Demonstration School (Elementary) in 2nd semester of 2022, which was obtained by purposive sampling. The tools used were 5 game-based learning lesson plans for 6th grade students (15 periods), a 30-item mathematics learning achievement test of 6th grade students and a satisfaction questionnaire on game-based learning management. The research design was the one group pretest-posttest and the statistics used were efficiency determination E1/E2, mean, standard deviation, and t-test for dependent sample. The research results were as follows: 1) The efficiency of process of game-based learning lesson plan which was developed for 6th grade students was 87.71 and the efficiency of product was 80.44 which complied to the defined criteria of 80/80; 2) After game-based learning management, 6th grade students had higher mathematics learning achievement of geometric shape and volume of rectangular shape than that of before learning at the statistical significance level of .01; 3) After game-based learning management, 6th grade students were satisfied with game-based learning management of geometric shape and volume of rectangular shape at the highest level.

Keywords: Game-based learning management, Mathematics learning achievement, Elementary education

[1]Srinakharinwirot University: Prasarnmit Demonstration School (Elementary), Faculty of Education, Srinakharinwirot University, Bangkok 10110, Thailand

[2]Behavioral Science Research Institute, Srinakharinwirot University, Bangkok 10110, Thailand

*Corresponding author, email: donsak@swu.ac.th

Introduction

Mathematics is the science that is very important to our daily lives by helping to develop human thinking, enabling humans think rationally, systematically, with a pattern, able to analyze problems carefully and thoroughly, and helping students to solve problems through forecasting, planning, and decision making which is very much useful to life on a daily basis. Therefore, mathematics helps to improve the quality of life [1]. In addition, mathematics is the basis of knowledge of science and modern technology. It can be said that mathematics is extremely important in the development of human qualities. With this importance, mathematics is therefore included in the curriculum at all levels of education so that learners have knowledge, understanding, and can bring and use information around oneself neatly and usefully. The component that had the highest impact on mathematics learning achievement was teaching quality [2]. Teaching methods or teaching techniques have a significant effect on quality teaching of mathematics. Therefore, teaching methods or teaching techniques must be developed in order to develop mathematics learning achievement.

Nowadays, the world has changed rapidly and the advancement in technology has changed everything around, including learning management. Boonthima C. said that good learning management should aim for learners to have positive changes in their thoughts, feelings, and actions called learning achievement [3], which Bloom BS. [4] said there were three variables that influenced: cognitive entry behaviors, affective entry characteristics, and quality of instruction. Moreover, Wilson JW. stated that mathematics learning achievement is the cognitive domain of learning mathematics [5]. We can combine game-type technology in learning to have more effective. Learning game is a type of learning media which encourages students to learn with fun by intervene content for students to learn through playing games [6]. Learning management by learning through games (games-based learning) is a learning method using games as a medium which can help develop children and youth in learning because it combines the fun of playing games as well as helping to attract learners. In addition, game helps develop the learning of learners quickly and encourage the brain to learn with fun which helps to solve learning problems that are boring, and require a lot of reading. Therefore, game has a very positive effect on learners [7, 8]. Learning through playing is one of the most effective ways of learning by doing (active learning). It helps to develop thinking and is something that children like, thus helping to create motivation for children to learn, especially nowadays with the spread of COVID-19 conforming with the findings of Yamkruan L. and Niwattanakul S. which indicated that 6th grade students of the experimental group who studied in a normal way combined with a game for learning had mathematical process skills, including problem solving skills, reasoning skills, communication and presentation skills, connection skills and creativity skills higher than the control group who studied normally alone and the experimental group had mathematical process skills after learning higher than before learning at the statistical significance level of .05 [9].

Management of learning through games (game-based learning) is considered an educational innovation that brings the fun of games and lesson content and design in a new way together, enabling students gain both knowledge and enjoyment at the same time especially in the form of a simulation game that creates a fun learning environment that makes learning not boring. Therefore, challenging game-based learning is an

attractive alternative for teachers to effectively arouse student interest and participation [10]. Game-based learning is not only a useful form of learning, but also a cost-effective learning model and an effective tool for learners to improve their learning outcomes as well [11]. Game-based teaching methods are methods that help learners to learn various subjects with fun and challenging by the learners as players themselves, resulting in direct experience as a method that allows students with high participation [12]. It is a learning activity in which the teacher integrates games into learning. Game based learning can be used in both the introduction into the lesson, teaching, assignment and evaluation stage [13]. Game-based learning management is a learning method that uses games as a medium. It can help develop children and youth in learning because it combines the fun of playing games as well as helping to attract the attention of the audience, helping develop the learning of learners quickly, encourage the brain to learn with fun and solve learning problems that are boring, not fun, and require a lot of reading. [7, 8]. This is consistent with Jirawarapong P. stating that learning games are a type of learning media that encourage students to learn with fun by inserting content for students to learn through playing games [6].

Game-based learning is a teaching method that makes learners highly engaged in learning, have fun and learn through playing. It helps learners to learn by seeing by themselves, making learning meaningful and durable as well as being a teaching method that is not very tired while teaching and students like it [14]. The management of learning through games has a very positive effect on the students because games help the brain to learn with fun. The brain, which has been learning with fun and enjoyment, releases happy substances called endorphins which this substance has a positive effect on the students. Instead, the brain releases a stressor called cortisol if students get stress and pressure to learn which is a negative effect for the body and is one of the reasons that lead to undesirable behavior of students such as skipping school or not being interested in studying, etc. Game-based learning management allows learners to learn content in a fun and experiential way and it provides an opportunity for learners to participate in teaching and learning because there is a student-centered teaching and learning activities in the classroom instead of lecture-only teaching [15]. This is conformed with the research of Amador-Alacron MP. et al which indicated that the use of Kahoot, a form of game-based learning, provided opportunities for university students to develop participation skill, helps build motivation and increase interest in learning [10].

From the story of game-based learning in education, it has been used in teaching and learning to develop learner motivation and learning outcomes. As seen from the examples of research results of various people, including Hanmongkolphiphat P. who conducted research on teaching and learning in the form of a game, the results showed that answering questions through the Kahoot game, the student answered the question correctly, representing 70.77 percent, with the students answering the question receiving the highest total score of 11,450 points, the lowest total score of 2,829 points, and an average total score of 8,009.52 points, and students have opinions that organizing teaching and learning activities in the form of Kahoot is a new teaching method that is different from traditional teaching, making learning fun and enjoyable. Students acquire knowledge and easily remember the content [16]. Boonsri. S, Ploysophon. A, and Im-ok R. did the research

on the results of using the game-based learning management in writing and spelling of 3rd grade students to compare the writing and spelling scores by learning management through games. The research results showed that the writing and spelling scores of 3rd grade students who studying with a game-based learning management were higher than before the study at the statistically significant level of .05 [17]. Taylyn H. et al did the research titled "From Here to There: A game-based approach to developing number sense and early algebraic understanding. The results revealed that after accounting for behavior within the app, playing the gamified version of the app contributed to higher learning gains than playing a nongamified version [18]. Eva. B. and Jeanette. S. did a research on playfulness and creativitty as vital features when school children develop game-based designs. The results indicated that in a mixed activity combining analogue and digital material, creativity in the form of fluency was represented by the way the children created their ideas, which opened up for playfulness, e.g. in the form of humour [19]. Sitti KA. et al conducted research on nominal group technique application towards design of components and elements of non-digital game framework. The research results showed that non-digital games are a tool that can help children to build and improve problem solving skills in early mathematics learning [20]. Parmjit S. et al conducted research on card games as a pedagogical tool for numeracy skills development. The results revealed that the math zaps card game is a highly effective learning tool in so far as the enhancement of students' numeracy computation skills in the areas of fractions, percentages and decimals are concerned [21]. Mee, RWM. et al conducted research on gamifying education for classroom engagement in primary schools. The results indicated that gamification carries the element of fun creativity into classroom teaching and respondents were in preference to learn using gamified learning activities that help them learn subconsciously [22].

Based on the experience of teaching mathematics, the researcher realized that learning about geometric shape and volume of rectangular shape for 6th grade students is difficult, and many students are unable to identify the components of geometric shape, unable to relate figure unfold to geometric shapes, and unable to convert units to find volume and capacity of rectangular shape. In converting unit from small to large or from large to small, students must remember the relations of different unit and be able to carry out correct unit conversions. However, many students did not remember the relations and were unable to perform unit conversions, resulting in low mathematics achievements in geometric shape and volume of rectangular shape for 6th grade students. From the above situation, it shows that 6th grade students of Srinakharinwirot University Prasarnmit Demonstration School (Elementary) still have mathematics learning achievement at a level that should be developed higher especially in geometric shape and volume of rectangular shape. For such reasons and importance, the researcher is therefore interested in developing the mathematics learning achievement on geometric shape and volume of rectangular shape including 1) characteristics and components of geometric shape, 2) an unfolded figure of geometric shape, 3) types of geometric shape, 4) volume and capacity, and 5) the problem solving of the volume of a rectangular shape for 6th grade students at Srinakharinwirot University Prasarnmit Demonstration School (Elementary) through game-based Learning Management. Moreover, game-

based learning management involves integrating games into students' learning in both the lesson introduction, teaching, assignment, and evaluation stages so that students can learn happily towards the set goals.

The purpose of this research was to create and determine the efficiency of game-based learning lesson plan on mathematics learning achievement of geometric shape and volume of rectangular shape, to compare learning achievement before and after game-based learning management, and to study satisfaction towards game-based Learning management of 6th grade students.

Research Conceptual Framework

This research has a research concept with learning organized through games as independent variable and Mathematics learning achievement in mathematics as dependent variable, as shown in Figure 1

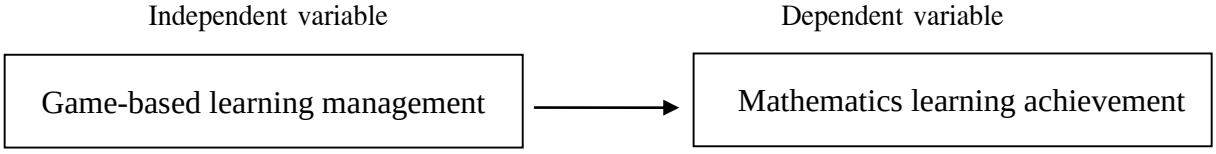

Figure 1 Research Conceptual Framework.

Materials and methods

Population and sample

The population was Srinakharinwirot University Prasarnmit Demonstration School (Elementary) 6th grade students in the second semester of the academic year 2022, totaling 8 classrooms (each classroom has mixed ability students). The total number of students was 240. The sample group consisted of 6th grade students in two classrooms, 30 students per classroom, totaling 60 students acquired by purposive sampling. Both classrooms are classrooms where the researcher normally teaches. The researcher used one classroom (30 students) to determine the efficiency of the game-based learning lesson plan. In another classroom (30 students), the researcher used in the experiment to compare the learning achievement before and after the game-based learning management and to study the satisfaction towards the mathematical game-based learning management on geometric shape and volume of rectangular shape.

Research tools

1. Game-based learning lesson plan

Game-based learning lesson plan for 6th grade students consisted of 5 learning units: characteristics and components of geometric shape, an unfolded figure of geometric shape, types of geometric shape, volume and capacity, and the problem solving of the volume of a rectangular shape. Each learning unit has learning management by integrating games into students' learning in 3 stages: Introduction, teaching and assigning work,

and evaluation stages There are a total of 18 learning lessons, each lesson is 50 minutes. With game-based learning management lesson plan, the researcher has created and passed a quality check from 5 experts. The results of the inspection found that all learning plans are of very good quality.

2. A mathematics learning achievement test

A mathematics learning achievement test of geometric shape and volume of rectangular shape for 6th grade students, 30 items (each correct answer receives 1 point, each incorrect answer receives 0 point), full score of 30, classified into characteristics and components of three-dimensional geometric figures, 6 questions (6 points), unfolded shapes of three-dimensional geometric figures, 6 questions (6 points), volume and capacity, 6 questions (6 points), and problems finding the volume of rectangular shapes, 6 questions (6 points). The test has validity value between .80 - 1.00, difficulty value between .20 - .80, discrimination value between .34 - .82 and reliability value of .84, which are the quality values of the test within the range that can be accepted [23].

3. A satisfaction questionnaire

A satisfaction questionnaire on game-based learning management of geometric shape and volume of rectangular shape for 6th grade students, which is a scale of 5 levels, 10 items (for each question, if answered with the least satisfaction, a score of 1, slightly satisfied, a score of 2, moderately satisfied, a score of 3, very satisfied, a score of 4, and the most satisfied, a score of 5), with a validity value between .80 - 1.00, discrimination value between .64 - .87 and reliability value of .93, which are the quality values of the questionnaire that is acceptable [24]

Conducting an experiment

1. Determining the efficiency of a game-based learning lesson plan

With an experiment to determine the efficiency of a game-based learning lesson plan on mathematics learning achievement, the researcher conducted an experiment with 30 students of 6th grade in the first classroom by teaching 5 learning lesson plans. After teaching each plan, each student did an exercise. After all, 5 lesson plans were completed, students were tested with a 30-item mathematics learning achievement test again.

2. Comparing the Mathematics learning achievement test before and after learning (Pretest/Posttest)

The researcher conducted the experiment by using the One Group Pretest-Posttest Design approach. In conducting this experimental research, the researcher proceeded according to the experimental design of one group pretest-posttest design [25] as shown in Table 1.

Table 1 An experimental model for effects of game-based learning management on learning achievement in mathematics on geometric shape and volume of rectangular shape of 6th grade students at srinakharinwirot university prasarnmit demonstration school (Elementary).

Pretest	Experiment	Posttest
o_1	x	o_2

when o_1 is pre-experiment test

x is teaching experiment using game-based learning management

o_2 is post-experimental test

With an experiment to compare learning achievement in mathematics before and after learning through games, the researcher conducted an experiment with 30 students of 6th grade in another classroom. Before teaching, the students were tested with the 30-item mathematics learning achievement test (Pretest), and then taught 5 learning leasson plans. When all lesson plans were done, the researcher once again tested the students with the 30-item mathematics learning achievement test (Posttest).

Data analysis

1. Analyzing the efficiency of the game-based learning lesson plan

The efficiency of the game-based learning lesson plan by finding the efficiency of the process or during use (Efficiency of Process: E1) with data from the measurements during the study and the efficiency of the results or after use (Efficiency of Product: E2) with the data from the measurements after the study were analyzed. The criteria for analyzing the Efficiency of Process (E1) and Efficiency of Product (E2) values are not less than 80/80.

2. Comparative analyzing of learning achievement

Comparative analysis of learning achievement in mathematics on geometric shape and volume of rectangular shape before and after game-based learning management with Mean ($\bar{x}$), Standard Deviation (SD), and dependent sample t-test was studied. The value of statistical significance was set at .05.

3. Analyzing the level of satisfaction

The level of satisfaction towards game-based learning management in mathematics of geometric shape and volume of rectangular shape for 6th grade students after learning management through the game by finding Mean ($\bar{x}$) and Standard Deviation (SD) was analyzed. The criteria for interpreting the mean are as follows: an average of 1.00 - 1.49 means that there is the least level of satisfaction, an average of 1.50 - 2.49 means that there is a low level of satisfaction, an average of 2.50 - 3.49 means that there is a moderate level of satisfaction, an average of 3.50 - 4.49 means that there is a high level of satisfaction, and an average of 4.50 - 5.00 means that there is the highest level of satisfaction.

Results and Discussion

1. The research results showed that learning management through games for 6th grade students at Srinakharinwirot University Prasarnmit Demonstration School (Elementary) consisted of 5 units: 1) characteristics and components of geometric shape, 2) an unfolded figure of geometric shape, 3) types of geometric shape, 4) volume and capacity, and 5) the problem solving of the volume of a rectangular shape. The efficiency of process was 87.71 (E1 = 87.71), and the efficiency of product was 80.44 (E2 = 80.44). The results were shown in Table 2.

Table 2 The effeciency of game-based learning lesson plan on learning achievement in mathematics on geometric shape and volume of rectangular shape of 6th grade students at srinakharinwirot University Prasarnmit Demonstration School (Elementary).

Game-Based Learning Lesson Plan (learning Unit)	Efficiency of Game-Based Learning Lesson Plan	
	E1	E2
1. Characteristics and components	87.67	80.44
2. An unfolded figure of geometric shape	83.67	
3. Types of geometric shape	92.67	
4. Volume and capacity	81.11	
5. The problem solving of the volume of a rectangular shape	93.42	
Mathematics Learning Achievement	87.71	80.44

Table 2, it was found that game-based learning lesson plan for 6th grade students at Srinakharinwirot University Prasarnmit Demonstration School (Elementary) consisting of 5 units, when used in teaching and learning with 6th grade students of Srinakharinwirot University Prasarnmit Demonstration School (Elementary) enabled the students to have mathematics achievements of geometric shape and volume of rectangular shape both during and after studying with an average score of 87.71 and 80.44 percent, respectively, which passed the specified criteria at 80 and 80 percent. The reason for this was due to the creation and determination the efficiency of game-based learning lesson plans on learning achievement in mathematics of geometric shape and volume of rectangular shape for 6th grade students at Srinakharinwirot University Prasarnmit Demonstration School (Elementary) this time was conformed with the principle of creating and determining the efficiency of educational innovation. The researcher started from studying basic information to see the definition and the nature of game-based learning management. Then, the researcher proceeded to create game-based learning lesson plans, brought to experts to examine and improve, experimented with 6th grade students of Srinakharinwirot University Prasarnmit Demonstration School (Elementary) to further study the results of development of mathematics learning achievement on geometric shape and volume of rectangular shape of

6th grade students, as mentioned about the concept of the process of creating a learning lesson plan of Phromwong C., Sinthaphanon S. and Wongyai. W. Those were said in consistent that creating or developing a learning lesson plan is a detailed task that requires carefulness and understanding in order to obtain a learning lesson plan that meets the objectives and must find the efficiency of the learning lesson plan in order to be used in organizing, teaching and learning activities effectively [26-28]. According to Malone TW.'s Motivation Theory, game-based learning will give learners motivation to learn: Challenge, Curiosity, Fantasy and Learner Control [29]. The results of this research are consistent with the research result of Sranamkam T. who found that the efficiencies of the web-based instruction using social media application to enhance knowledge management skills on computer tablet for teachers were 84.25/82.75, which is higher than the performance criterion set at 80/80 [30] and the research result of Puntuta W. et al who found that the efficacy value of using the instructional packages based on Directed Reading - Thinking Activity (DR-TA) method for 7th grade students was defined as 83/84 that was higher than the expected standard of 80/80 [31].

2. The research results showed that after the game-based learning, the students' mathematics achievement on geometric shape and volume of rectangular shape was significantly higher than before learning at the .01 level, which was shown that learning through games can make 6th grade students of Srinakharinwirot University Prasarnmit Demonstration School (Elementary) had a higher learning achievement in mathematics on geometric shape and volume of rectangular shape than before teaching with 99% confidence which were shown in Table 3.

Table 3 Mean, standard deviation, and test results of the difference of learning achievement before and after using game-based learning lesson plan in mathematics on geometric shape and volume of rectangular shape of 6th grade students at srinakharinwirot University Prasarnmit Demonstration School (Elementary).

Experiment	n	$\bar{x}$	SD	t	p-value
Before class	30	18.73	5.09	8.245**	.000
After class	30	24.13	4.28		

** with statistical significance at the .01 level

In table 3, it was found that before applying game-based learning lesson plan in mathematics on geometric shape and volume of rectangular shape, 6th grade students had average learning achievement of 18.73 ($\bar{x}$ = 18.73) with a standard deviation of 5.09 (SD = 5.09). After applying game-based learning lesson plan in mathematics on geometric shape and volume of rectangular shape, 6th grade students had average learning achievement of 24.13 ($\bar{x}$ = 24.13) with a standard deviation of 4.28 (SD = 4.28). When comparing the mean before and after applying game-based learning lesson plan in mathematics on geometric shape and volume of rectangular shape, students had higher average learning achievement than before applying game-based learning lesson plan with statistical significance at .01 level (t = 8.245, p-value < .01). The reason for this may be due to game (Game-Based Learning) is considered an educational innovation that combines the

fun of games and lesson content which was designed to be in a new way together whether it is 1) the lesson introduction stage, 2) the teaching assignment stage, and 3) the evaluation stage, enabling students gain both knowledge and enjoyment at the same time especially in the form of simulation games that create fun learning environment, making learning not boring and challenging, which will make learning more efficient. This is in line with the concept of Suankan C., which states that games have content and images that are consistent with learning combined with a process that promotes learning, resulting in intellectual and analytical thinking process development [32]. In addition, it is consistent with the concept of Bloom BS. stating that good learning management has an important element to increase effectiveness in teaching and learning, namely: there are guidelines (Cues) that make the learner knows what will happen to the students after studying [33]. Participation reinforcement, feedback and corrections are another important elements in effective learning management. Game-based learning management has mentioned characteristics, resulting in higher learning achievement in mathematics. The results of this research are consistent with the research result of Pearl EE. and Eberechukwu AS. who found that the scientific card game designed in the study, Pictionary and Matching card games, can help students in gaining knowledge regarding forms of transportation and energy. The posttest scores of the students (M = 92.13, SD = 8.80) were significantly higher than the pre-test scores (M = 83.33, SD = 11.43) ($t = -3.319$, $p < 0.01$) [34]. and the research result of Idris MI., Said NEM. and Tan KH. who found that the performance of students in the post-test improved significantly (M = 5.61, SD = 2.04) with the application of Kahoot! as compared with that in the pre-test (M = 3.35, SD = 1.89)($t = -5.550$, $p < 0.05$) [35].

3. The research results showed that after organizing learning through games of 6^{th} grade students at Srinakharinwirot University Prasarnmit Demonstration School (Elementary), the students had overall satisfaction with learning through games at the highest level especially in terms of games that make students have fun and interesting. Game-based learning gives students a sense of participation in the classroom and the exam content is consistent with the knowledge learned. It was shown that learning through games gave students the greatest satisfaction in learning mathematics on geometric shape and volume of rectangular shape as shown in Table 4.

Table 4 Mean, standard deviation, and satisfaction level toward game-based learning management in mathematics on geometric shape and volume of rectangular shape of 6th grade students at Srinakharinwirot University Prasarnmit Demonstration School (Elementary).

Satisfaction level toward Game-Based Learning Management in Mathematics	$\bar{x}$	SD	level
1. Student felt that the teachers had clearly explained the objectives	4.53	0.57	Highest
2. Student felt that the content was useful for learning	4.60	0.49	Highest
3. Student felt that the ordering of the contents was appropriate	4.53	0.62	Highest
4. Student felt that the game activities helped them understand the content well	4.56	0.67	Highest
5. Student felt that the game was fun and interesting	4.76	0.56	Highest
6. Student felt that the time spent in organizing activities was appropriate	4.33	0.75	High
7. Student felt that learning through games made them participate in the classroom	4.70	0.59	Highest
8. Student felt that the contents of the exam are consistent with the knowledge they have learned	4.67	0.66	Highest
9. Student felt that they were happy with the exercises after learning	4.33	0.84	High
10. Student felt that they study happily	4.63	0.71	Highest
Overall	4.56	0.44	Highest

In table 4, it was found that after learning management through games, 6th grade students were overall satisfied with learning management through games at the highest level ($\bar{x}$ = 4.56, SD = 0.44). When considering item by item, it was found that there were 8 items that the students were satisfied with the highest level, which was ranked in order from highest to lowest average respectively; item 5, student felt that the game was fun and interesting ($\bar{x}$ = 4.76, SD = 0.56), item 7, student felt that learning through games made them participate in the classroom ($\bar{x}$ = 4.70, SD = 0.59), item 8, student felt that the contents of the exam are consistent with the knowledge they have learned ($\bar{x}$ = 4.67, SD = 0.66), item 10, student felt that they study happily ($\bar{x}$ =4.63, SD=0.71), item 2, student felt that the content was useful for learning ($\bar{x}$ = 4.60, SD =0.49), item 4, student felt that the game activities helped them understand the content well ($\bar{x}$ = 4.56, SD = 0.67), item 1, student felt that the teachers had clearly explained the objectives ($\bar{x}$ = 4.53, SD = 0.57) and item 3, student felt that the ordering of the contents was appropriate ($\bar{x}$ = 4.53, SD = 0.62). There were 2 items that the students were equally satisfied with at a high level which were item 6, the students felt that the time spent in organizing activities was appropriate ($\bar{x}$ = 4.33, SD = 0.75) and item 9, student felt that they were happy with the exercises after learning ($\bar{x}$ = 4.33, SD = 0.84). The reason for this may be that learning through games is a teaching method that makes learners highly engaged in learning. The students learn with fun and learn through play. It helps students to learn manifestly, making learning meaningful and durable as well as being a

teaching method that is not very tiring while teaching and students like it [10]. In addition, learning through games is considered one of the learnings through play which is active learning that is effective in developing thinking and is something that learners like. This is in line with the idea of Bunyanukul A. that games make learners interested and enjoy learning [36] and the idea of Suksai J. that inserting games into learning activities helps to create a fun and relaxing learning atmosphere [37]. In addition, it is consistent with Plensky's concept which indicated that game-based learning can create participation (Engagement) in learning for learners because games are fun, allowing learners to enjoy hands-on or practical experiments based on experimental learning (Learning by Doing) [38]. The results of this research are consistent with the research result of Nadeem M., Oroszlanyov M., and Farag W. who found that digital game-based learning has a more positive impact on student engagement and motivation compared to traditional online activities. The positive response from students toward digital game-based activities shows that enhancing game-based learning will not only make learning an enjoyable experience for students but also enhance their engagement [39] and the research result of Liu EZF. and Chena P. who found that the students demonstrated positive attitudes toward the use of the educational card game in science learning [40].

Conclusion

Game-based learning lesson plan on mathematics of geometric shape and volume of rectangular shape which was developed for 6^{th} grade students' efficiency of process value was 87.71 and efficiency of product was 80.44. After game-based learning management, 6^{th} grade students had higher mathematics learning achievement than that of before learning at the statistical significance level of .01 and students were satisfied with game-based learning management at the highest level.

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