Matching Online Game-Based Learning (MOGBL) about Counting, Addition and Subtraction in Case of Lower Elementary Student with Intellectual Disabilities

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Abstract

This research aims to find the effectiveness of matching online game-based learning (MOGBL) about counting, addition, and subtraction according to Meguigans' criteria. Moreover, this research finds along with studying the progress of students' learning and the relationship between desirable characteristics of students learning with math and learning achievement after learning with these games. The samples used in this study were seven students with intellectual disabilities learning in lower elementary of Surin school for the deaf. Tools used in the operation are matching online game-based learning, pre-test, post-test and the eight desirable characteristics of students according to the basic education core curriculum B.E. 2551 (A.D. 2008) along with applying the Pearson product-moment correlation coefficient for analysis. The results showed that the online game developed was as effective as 1.73 which was according to Meguians' criteria, required to more than 1.0. Besides, it was found that the students had learning progress, accounted for 41.45 percent. While the desirable characteristics of students were not positively correlated with learning achievement after learning, showing statistically significant difference at the level of 0.05 ($r = -.283$, $p > 0.05$). Thus, it can be clearly seen that the developed online game is more preferable for the deaf student. Also, it helps to reduce inequality in education. As a result, a student with learning disabilities could learn as much as normal students.

Keywords: Online Game Based Learning, Matching Game, Math Game, Students with Intellectual Disabilities.

1. Introduction

Education is important for life, quality development of life, and human well-being. As Thai rhetoric said that "if the foundation of the building is brick, the foundation of life is education". Therefore, Education is something that everyone must be given priority. It can be clearly seen that most people are highly successful because of a good education [1]. The development of quality people depends on the opportunity of obtaining an effective education. Therefore, it is necessary to arrange the education to suit the needs of the students so that they can develop their knowledge to their full potential.

Students with intellectual disabilities are one of nine types of disabilities, announced by the Ministry of Education about determining the type and criteria for persons with disabilities Act B.E. 2552 [2]. These children with a special need may not receive a full benefit from education like normal children [3] because these children's brains have stopped development or incomplete development which causes defects in various skills. As a result, there are inherent limitations of reading, writing, speaking and listening as well as mathematical calculations [4]. As a result of those students are unable to do and learn anything, compared with friends of the same age [5]. It especially is difficult to learn and compete like a normal child in terms of educational results. According to the desirable characteristics of the students, the basic education core curriculum is required to emphasize developing knowledge along with morality [6]. Thus, education for these children with disabilities should be focused on helping themselves as much as possible to assist them to live and adjust in society happily [7].

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Mathematics is an educational tool of science and technology which can be applied all discipline. Therefore, it plays a crucial role in the development of human thinking leading to more beneficial to living and improving the quality of life such as creative thinking, logical thinking, systematical thinking, and analyzing problems and situations carefully toward complete humans [8]. Counting, addition, and subtraction are parts of mathematics that lead to application in daily life, starting from traveling, time, buying, and finance and banking as a basis for education [9]. It can be seen that these mathematical skills are essential to every human life, including people with intellectual disabilities [10]. Therefore, teaching and learning about basic math skills for students with intellectual disabilities usually distracted behavior and love to play, and poor comprehension in learning, is highly important that teachers and stakeholders must create motivation and stimulate interest for this group of students [11], [12]. Learning through play is an alternative way to create interest, fun, and challenges in learning.

Game-based learning (GBL) is another way of the teaching and learning process which the students must play to learn or learn with fun and as a result of relieving stress in the classroom [13]. It has been applied since pre-elementary, elementary and secondary [14]. In spite of the fact that the GBL is also a tool for developing children's intelligence [15]. It has colors, lights, and sounds that stimulate students to become curious, resulting in students' higher learning achievement. The GBL consists of rules, explanations, and correct practices [14] which can be presented in varieties of a type such as adventure game, role-playing game, card game, word game, board game, matching game, and fighting game. These games are more useful for education. Especially matching game usually suitable for young students and instructional game, they aid in developing basic math skills and analytical thinking [16], [17].

Nowadays, computer technology and Internet network are integrated with GBL resulting in it to become an online game-based learning or computer-assisted instruction game helping students to play and learn any time and anywhere. In addition, multimedia technology is used to develop games because there are lights, sounds, animations, and interaction between players that are more attractive [18]. However, if online game integrated with learning about counting, addition, and subtraction, they enhance to stimulate the interest of students with intellectual disabilities and can also live happily in society.

For all the above reasons, the researchers would like to investigate matching online game-based learning (MOGBL) about counting, addition, and subtraction in the case of a lower elementary student with intellectual disabilities. The purposes of this study were to find the effectiveness of MOGBL and to study the progress of students' learning and the relationship between the desirable characteristics of students who studied with mathematics and learning achievement after learning with this online game. While, there are three hypotheses: Firstly, MOGBL about counting, addition, and subtraction in the case of a lower elementary student with learning are effective as the Meguians' criteria (more than 1.0). Secondly, students who studied with this online game has higher learning progress. Finally, desirable characteristics of students studying with mathematics and learning achievement of students who learn with this online game having positive relationships with a statistically significant difference at 0.05 ($p<0.05$).

2. Theoretical Background and Related Researches

2.1 Game-based Learning Management

Game-based learning is an activity that helps promote and develop systematic thinking. The game must be under the rules and conditions. In addition, it encourages students to learn according to the learning objectives and there are summarized results of playing game to students [13], [19]. However, N. Nakasan and Ch. Nakasan [18] suggested that instructional game did not mean creating to play only. But it must have been elements of games such as competition, rule, participation, and rewards to design learning activities.

Game-Based Learning with mathematics is activities that may be played individually or groups in mathematics. Each game must have clear rules, objectives, and playing [19]. The teacher can choose a variety of games as appropriate which each type of game has different objectives and details, such as matching game for observation and comparison, sorting game for practicing skills, classification, predictions [16]. For this study, the researchers selected matching game to practice skills of observation and comparison about the number counting, addition, and subtraction, which are basic mathematics that will be most useful for students in the future.

2.2 Instructional Computer Game

M. Tiantong [20] said that the goals of the development of computer-assisted instruction with game is to practice and review lessons. There are presentations that fun, exciting and invite students to follow more lessons. Instructional game is more useful in learning and teaching for young children, as this group needs more motivation than other levels. As well as, S. Billbai and S. Thanamai [21] said that instructional computer game is play activities that combine computer technology and multimedia technology and can be presented via the internet. Students can learn any time, any place, with the rules, competition, fun, challenge, imagination, and safety as important elements.

From the definition and features of the game above, it can be seen that the game is play activities along with the learning of everyone. Especially students with intellectual disabilities that stakeholders must create instructional game to meet their needs.

2.3 Children With Intellectual Disabilities

Children with intellectual disabilities have an intelligence quotient (IQ) lower than average, problems in handle myself in daily life and show symptoms before 18 years of age [2], which can be classified into four levels of intellectual disability [2], [22] as follows:

2.3.1Mild mental retardation: This group of students can learn up to grade 6 and can have a career for an easy job.

2.3.2 Moderate mental retardation: These students can learn up to grade 4 and practice basic skills that are not very complicated.

2.3.3 Severe mental retardation: These students cannot learn but can practice simple basic skills to aid themselves.

2.3.4 Profound mental retardation: This group of students cannot assist themselves. They must be given special care.

2.4 Teaching and Learning for Children with Intellectual Disabilities

Arayawinyu [5] proposed the concept of instructional for children with intellectual disabilities that can learn as follows:

2.4.1 Early childhood education: This education level should focus on skills that are fundamental to the elementary level, such as thinking, memory, society, and emotions.

2.4.2 Primary education: First, it should focus on reading skills, mathematics, language, science, and society respectively.

2.4.3 Secondary education: It should mainly focus on the needs and abilities of students. If the teacher wants to focus on academics and students can learn, students should be encouraged to study subjects that are appropriate for their ability. But on the other hand, if the teachers want to focus on a career, they should encourage students to practice skills that can be in society.

In addition, Arayawinyu [5] explained that because these students have no ability to learn advanced mathematics like normal students. Therefore, teaching and learning should focus on the contents that correspond to their needs and abilities, as well as applications in daily life. Teaching about counting does not always have to use a finger, but it could be used as a symbol. Similarly, the calculation should use examples related to daily life for the students to understand more easily. In addition, reading skills should be taught along with the interpretation of the problem, because these students have poor concentration and a short attention span. Therefore, the training of various skills should not take a long time because it may result in the teaching is unsuccessful.

2.5 Desired Characteristics of Students

The desired characteristics of the students are eight aspects of behavior following the basic education core curriculum B.E. 2551 (A.D. 2008). To be able to live happily with family and society as a citizen of Thailand and the world such as love of nation, religion and king, honesty and integrity, discipline, avidity for learning, applying principles of sufficiency economy philosophy in one's way of life, commitment to work, cherishing Thai nationalism, and public-mindedness [6].

2.6 Literature Review

Previous research about the relationship between learning achievement and desired characteristics and learning behavior are as follows:

Chevasutho [23] studied and researched the relationship between learning behavior and learning achievement of third-year students in the nursing science program at Boromarajonani College of nursing, Chon Buri. It was found that students' learning behavior was related to learning achievement ($r=2.219$, $p<0.01$).

Khoato [24] investigated desirable characteristics and academic achievement of Mathayomsuksa three students of the Saparachinee Trang School. The research found that desirable characteristics include discipline, avidity for learning and cherishing Thai-ness had positively correlated with learning achievement at low levels, while the desirable characteristics of public-mindedness had a negative relationship with learning achievement at low levels.

The researches related to computer teaching game are shown as follows:

Suttijak and Youngmee [25] studied 2D animation game to develop the skill for classifying colors, sizes, and geometric forms for children with moderate mental retardation. It was found that the students' learning outcomes were higher than after using this game, which most children develop skill in color classifying, geometric forms and sizes respectively.

Sriwatphong and Pimolbunyong [26] studied the results of using computer-assisted instruction with game for mathematics about multiplying by 2-digit numbers of Prathomsuksa 3 students, which found that this instructional game was as effective based on defined criteria. Besides, there are still found that students had higher learning progress.

Yamkuan and Niwattanakul [27] studied and researched about using game-based learning to promote mathematics process skills of Prathomsuksa 6 students, the results showed that the learning achievement of the students was higher. Besides, there was a suggestion that if the game was used correctly, they aid to create good interaction between the students and the teachers.

Bonet-Codina, von Barnekow and Tost [28] researched design game based on a real case of professional integration (IntegraGame) with a group of students with intellectual disabilities. The results showed that the students had fun and learned from game. Game can improve the learning of students with intellectual disabilities.

The above research, it can be concluded that instructional games are an effective educational tool because games motivate the students' interests and challenges. Especially, if they are a computer game-based learning and mathematics, they will enable the students to benefit both fun and develop knowledge together.

3. Research Methodology

3.1 Population and Sample

3.1.1 The population was lower elementary students with learning disabilities under the Surin special education center.

3.1.2 The sample was purposive sampling from seven students with intellectual disabilities in the lower elementary of Surin school for the deaf. This group of students had passed the assessment of learning development which was a group that can learn and comes to study regularly. However, due to the limited number of sample groups, it was the result of the inconvenience of parents to took students to a segregated special school such as distance, cost. In addition, the Surin school for the deaf has a person with special

education, therefore able to provide education for this group of children. The reason for selecting this sample was students that could not calculate and solve math problems. The school focuses on professional skills to encourage students that are able to carry on an occupation when they finished. However, students had low skills in counting, addition, and subtraction. If they had not helped, it will have a long-term impact.

3.2 Variables

3.2.1 The independent variable was matching online game-based learning (MOGBL) about counting, addition, and subtraction.

3.2.2 The dependent variable consisted of the efficiency of learning with MOGBL, students' progress of learning and the relationship between the desirable characteristics of students who studied with mathematics and learning achievement with MOGBL.

3.3 Developing and Finding the Effectiveness of Matching Online Game-based Learning

Matching online game-based learning was developed with the ADDIE Model [19], [29] which have 5 steps are as follows:

3.3.1 Analysis (A): There were job analyses, determination of knowledge to obtain the title and contents about counting, addition, and subtraction follow the basic education core curriculum for students with intellectual disabilities Act B.E. 2551 [30]. In this content analysis, there were six lessons from the three units, the details and example shown in Table 1 and for example in Figure 1.

Table 1. *Task analysis inventory.*

Task	Subtask
1. Counting	1.1 numbers 1 to 5 counting and 0 1.2 numbers 6 to 10 counting 1.3 numbers 11 to 15 counting 1.4 numbers 16 to 20 counting
2. Addition	2.1 Addition of two numbers with a sum less than 9
3. Subtraction	3.1 Subtraction of two numbers not greater than 9

3.3.2 Design (D): The learning outcomes were designed that can be observed and measured as well as designed forty-eight behavioral objectives. Next, MOGBL

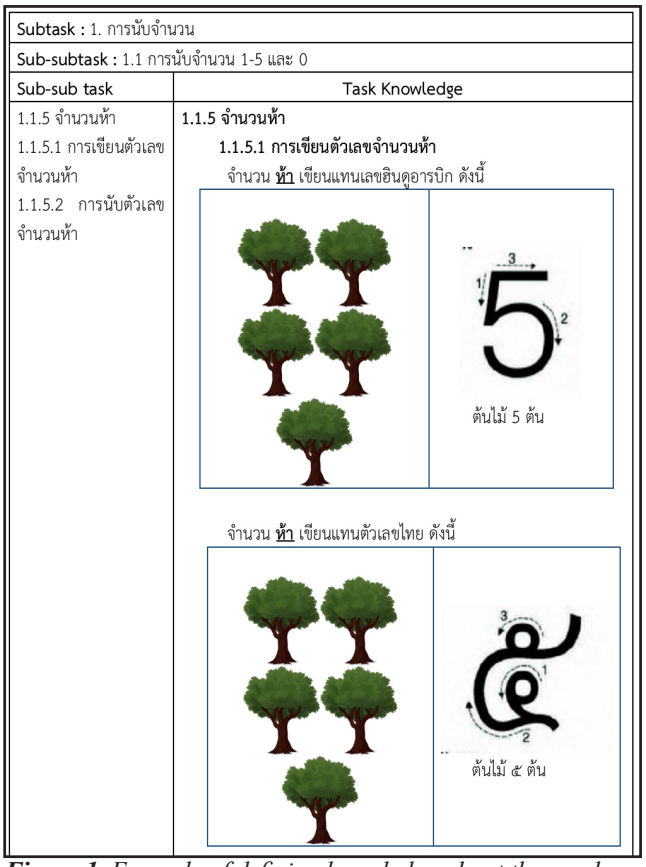

Figure 1. *Example of defining knowledge about the numbers 1 to 5 counting and 0.*

was designed according to behavioral objectives and contents. There were one hundred and twenty-six games in three units the details shown in Table 2, for example in Figure 2.

Table 2. *Task inventory and number of games.*

Task	Subtask	Number of games
1. Counting	1.1 numbers 1 to 5 counting and 0	30
	1.2 numbers 6 to 10 counting	25
	1.3 numbers 11 to 15 counting	25
	1.4 numbers 16 to 20 counting	25
2. Addition	2.1 Addition of two numbers with a sum less than 9	12
3. Subtraction	3.1 Subtraction of two numbers not greater than 9	9
Total of games		**126**

Next time, the online game was sent to content experts to evaluate the consistency between them and the learning objectives. The evaluation found that experts agreed that the online game was consistent with the learning objectives.

Subtask : 1. เกมการนับจำนวน		
Sub-subtask : 1.1 เกมการนับจำนวน 1-5 และ 0		
Sub-sub task	Object (TPO/EO)	Games
1.1.11 จำนวนห้า	1) เมื่อให้เนื้อหาเกี่ยวกับการเขียนตัวเลขจำนวนห้าในรูปแบบเลขไทย ผู้เรียนสามารถเขียนตัวเลขจำนวนห้า ในรูปแบบเลขไทยได้	คำชี้แจง ลากจับคู่ภาพกับวิธีการเขียนตัวเลขไทยให้ถูกต้อง 

Figure 2. *Examples of game design about the numbers 1 to 5 counting and 0.*

After the achievement tests were designed into three choices, they were evaluated for consistency with the behavioral objectives by content experts. It found that the tests and objectives were consistent. Next time, there was a quality testing of tests in which they were tried on students who had studied mathematics. It found that the tests had quality with the criteria. Then, the tests were divided into 2 sets for pre-test and post-test. Finally, there were designed of storyboard and system flowchart to the guideline for developing online game (Figure 3).

3.3.3 Development (D): At this stage, the each game was developed as designed. Examples show in Figure 4 to Figure 7.

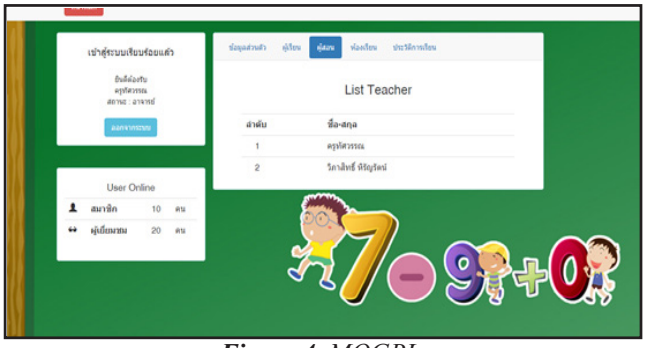

Figure 4. *MOGBL.*

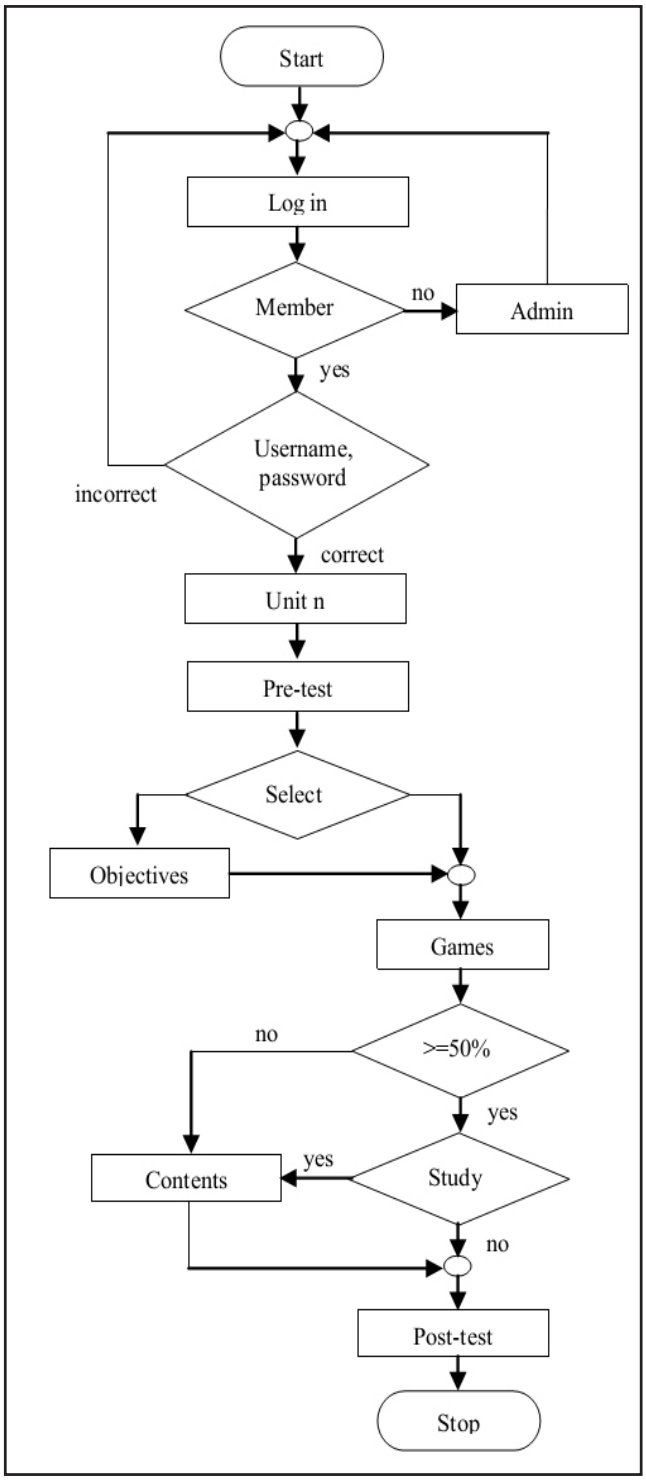

Figure 3. *System flowchart design.*

However, there was evaluated the quality of game during the development which tryout with non-sample groups.

3.3.4 Implementation (I): guidance manual had been developed and game had been installed via network system with URL:http://computer.surin.rmuti.ac.th/sujittra/twitch/index.php

3.3.5 Evaluation (E): The online game was evaluated by 5 technical and method experts. Overall, it was found that the average was 4.00 and the standard deviation was 0.20, which showed that they had accepted the online game [31].

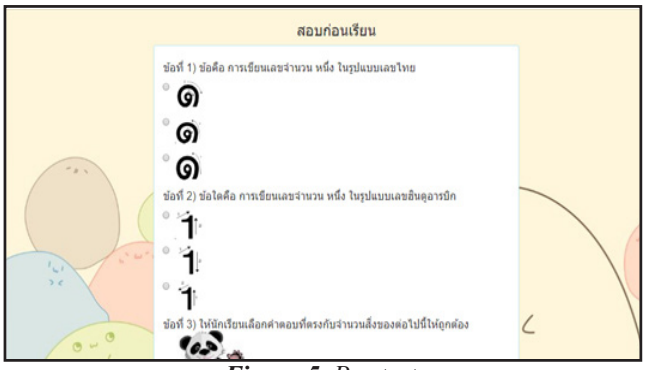

Figure 5. *Pre-test.*

Figure 6. *MOGBL: Writing numbers 2 with Thai numerals.*

Figure 7. *MOGBL: number subtraction with the sum less than 9.*

3.4 Data Collection

3.4.1 Sending the letter to the director of the Surin school of the deaf for data collection and the result's the desired characteristics in mathematics.

3.4.2 Explaining how to use MOGBL for teachers and one on one with seven students in the second semester, the academic year 2018.

3.4.3 Students accessed to the online game via the internet, as the detail below:

1) Students logged in to the online game.

2) Next step, Students selected any topic that they want to study.

3) Before studying, students took the pre-test

4) After the pre-test, they could select to study the learning objectives and play the game on that topic. The details of the game presentation were as follows:

4.1) Motivation: There was using of multimedia motivate the interest of students.

4.2) Instructional: There was providing content through instructional game.

4.3) Skill training: Students had to play the game. Each game had the rule as follows:

• f the score was less than 50 percent, the students had to study the content again.

• If the score was equal and more than 50 percent, the students could select to study or not study the content.

• Answers and summary: There was a correct answer in each game. In addition, the system also reported learner's scores in each game to the students to know about the success of playing game.

5) Contents: They consisted of the contents about counting, addition, and subtraction.

6) When students were finished playing the game or studying, after that, they took the post-tests, to measure the learning effectiveness of each topic.

3.4.4 Data were collected and analyzed as follows:

1) Finding the efficiency of matching online game-based learning according to Meguigans' criteria [20] from pre-test and post-test scores.

2) Finding students' progress with the effectiveness index (E.I) of P. Kidrakarn and S. Pattiyathanee [32], which formula is E.I = (P2- P1)/(Total-P1), It could explain that numerator of E.I is difference between all students' the post-test score (P2) and pre-test score (P1). The denominator was the difference between all students' the pre-test score (P1) and total which it was multiplication between a number of students and total score.

3) Finding the relationship between desired characteristics and students' learning achievement post-test with Pearson's Product Moment Correlation Coefficient [33] and variable relationships [34].

4. Results

4.1 H0: MOGBL about counting, addition, and subtraction in the case of a lower elementary student with learning was not as effective as the Meguians' criteria.

H1: MOGBL about counting, addition, and subtraction in the case of a lower elementary student with learning was effective as the Meguians' criteria.

The result of the effectiveness of MOGBL with Meguigans' criteria, It was found that 126 total scores, seven students had the average pre-test class point score was 45.71 and a post-test average score of 79.00. These MOGBL had an efficiency of 1.73, which was higher than the criteria of Meguigans (more than 1.00) (Accept H1 and Reject H0). It shows in Table 3.

Table 3. *The results of the effectiveness of online game.*

Students (N)	Total score	Average of test		Efficiency
		Pre-test	Post-test	
7	126	45.71	79.00	1.73

4.2 H0: Students who studied with MOGBL had not higher learning progress

H1: Students who studied with MOGBL had higher learning progress

The 126 total scores when analyzed to the learning progress of all students who studied with this online game. All students' pre-test was 320 points and 553 points on post-test. The overall showed that students' scores increased to 0.4145 (41.45 percent) which details shown in Table 4. In this case, we accepted the alternative hypotheses (H1) and reject the null hypotheses (H0).

Table 4. *The results of the students' learning progress.*

Multiplication between number of students and total score	Average of test		E.I
	Pre-test	Post-test	
7x126	320	553	0.4145

Considering the individual students' points on pre-test and post-test (126 total scores), it found that the first student had 32 points on the pre-test, (25.40 percent) post-test 68 points, (53.97 percent) which both tests had a difference of 36 points or 28.57 percentage point. The second student 's pre-test had 57 points (45.24 percent), and the score of the post-test was 85 (67. 46 percent). Third, She/he had scores of pre-test and post-test were 44 and 72 points or 34.92 and 57.14 percent respectively. Both the second and third students' pre and post-test had a difference of 28 points or 22.22 percent. The fourth learner, with 36 points on the pre-test, (28.57 percent), while the score of the post-test was 71, (56.35 percent), the difference between both of the tests was 35 points or 27.78 percent. Pre-test score, the fifth student had 57 points (45.24 percent), and 96 points on post-test which was equivalent to 76.19 percent. The difference between pre-test and post-test was 39 points which were 30.95 percent. The 6th learner had 53 pre-test points, which was 42.06 percentage point, while the post-tests were 84 points, it was 66.67 percent. The difference between pre and post-test was 31 points, (24.60 percent). The finally, he/she had 41 points, percent of 32.54 of pre-test, while the 77 points or 61.11 percentage of post-test, which both tests had to score difference of 36 points or percent of 28.57. Based on the findings, it was concluded that the students got more score after studying with the online game which the details as in Table 5.

Table 5. *The result of percentage and difference of scores on tests.*

No.	Tests (126 total scores)				Difference of pre and post-test	
	Pre-test		Post-test			
	Score	Percent	Score	Percent	Score	Percent
1	32	25.40	68	53.97	36	28.57
2	57	45.24	85	67.46	28	22.22
3	44	34.92	72	57.14	28	22.22
4	36	28.57	71	56.35	35	27.78
5	57	45.24	96	76.19	39	30.95
6	53	42.06	84	66.67	31	24.60
7	41	32.54	77	61.11	36	28.57

4.3 H0: Desirable characteristics of students studying with mathematics and learning achievement of students who learned with this online game had no positive relationships with a statistical significance difference at 0.05 ($p<0.05$).

H1: Desirable characteristics of students studying with mathematics and learning achievement of students who learned with this online game having positive relationships with statistically significance difference at 0.05 ($p<0.05$).

The result of the relationship of desired characteristics of students with mathematics and learning achievement of students with MOGBL

The correlation coefficient was determined by Pearson's product-moment correlation to the analysis of the relationship of desired characteristics of students with mathematics and learning achievement of students with developed online game. It was found that the correlation coefficient was -2.83 and the sig. (2-tailed) was 0.538, which it's greater than the value specified ($\alpha<0.05$), and did not conform to the alternative hypotheses (H1). It showed that the little and opposite relationship between desirable characteristics and learning achievement for seven students as in table 6.

Table 6. *The result of the analysis of the relationship students' desired characteristics and learning achievement.*

	Desired characteristics	Score of learning achievement	Sig.
Desired characteristics	1.00	-.283	.538
Score of learning achievement	-2.83	1.00	

*($p<0.05$)

5. Conclusions and Discussion

5.1 Hypotheses 1: MOGBL about counting, addition, and subtraction in the case of a lower elementary student with learning was effective as the Meguians' criteria, showing more than 1.0.

This game was effective according to Meguigans' criteria because of this online game designed and presented content, sound, still images and animation which stimulates and reduces boredom for learning. It also helped the students to understand the content more easily which is similar to the research of Yamkuan and Niwattanakul [27], Wattanawong [35] and Aikaterini and others [36]. It was also consistent with the research of S. Moonkam and O. Moonkam, Tiantong [19-20], Bonet-Codina and others [28] and Billbai andThanamai [37] found that students was half the fun of learning and knowledge from their participation in the game activities. In addition, gams also helped to increase challenges and reduce boredom class as well as allowing students to be aware of their learning progress. However, the game was designed and developed with the ADDIE Model. As a result, this online game had quality and could be delivered content to the students more efficiently. This was consistent with the research of Sriwatphong and Pimolbunyong [26] and Soriyot and Hiranrat [38] that there were designed and developed online learning based on the principles ADDIE model.

5.2 Hypotheses 2: Students who studied with MOGBL had higher learning progress.

The results lead to conclude that the percentage increases in students' learning progress were 41.45. Because the developed game had activities depictions that focus on the students to challenge, curiosity along with learning turns to be helped the students to learn better and higher learning which these results correspond with Sriwatphong and Pimolbunyong [26] who studied about results of using computer lesson game format in Mathematic entitled the two digits multiplication for Prathomsuksa 3 students and found that the students had higher 62 percent of learning progress. While Thangsathirasima and Khanto [39] found that using game to improve the English communication skills of Prathomsuksa 5 students, the students had scores of English language skills higher than the criteria. As well as the Bojakrapan and others [40] that using game-based learning about adding numbers up to 1,000 for Prathomsuksa 2 students, it was found that the student's knowledge increased from the previous 62.22 percent. Which it corresponds with Laohapaitoon and Phoyen [7] that using game to promote the

ability to write 3 Digit Numbers for students with intellectual disabilities which found that students can write 3 digits after using with the game was higher than before.

5.3 Hypotheses 3: Desirable characteristics of students studying with mathematics and learning achievement of students who learned with this online game having positive relationships with a statistical significance difference at 0.05 ($p<0.05$).

The desirable characteristics of students were very low and opposite correlated with learning achievement after learning. They reflected that eight desirable characteristics did not cause any difference in learning achievement. It took a long time as opposed to learning that did not take much time. Therefore, the desirable characteristics had very little relationship to the learning achievement or it caused discrepancies in the evaluation of other desired characteristics, which had other factors that the researcher had not studied. Nevertheless, the reported previous study of W. Khoato [24] studied each desirable characteristic that affected the student's learning achievement. The results showed that three desirable characteristics including discipline, avidity for learning and Thai nationalism that had a positive correlation while public-mindedness had a negative correlation with learning achievement at a low level. It can be seen that each item of desirable characteristics has both positive and negative correlation with learning achievement. Besides, Chevasutho [23] also explained additional that the students would not succeed in studying; it was not related to the learning behavior of the student. Because of both learning behaviors, skill or learning style was characteristic of students which they would regular expression in learning.

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