

A Study of gamification on *GeoGebra* for remedial pupils in primary mathematics

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Abstract

Remedial pupils are often more engaged in their learning when the content delivered uses games-based-activities. This study integrated gamification using technology in learning mathematics which is one of the 21st century learning approaches. In this paper we report the results of a study on lessons using 2 learning games based on GeoGebra with reference to remedial pupils' motivation in learning primary mathematics. The respondents consisted of 4 remedial pupils from a primary school in Selangor, Malaysia. Data were obtained through observation on lessons and questionnaire on students' perception in gamification on GeoGebra. Observation by using video recording indicated that the sample showed high motivation in learning mathematics. Questionnaire result also showed students' positive interest in using gamification on GeoGebra. In conclusion, this study found that using gamification on GeoGebra is highly effective in helping remedial pupils to learn primary mathematics besides increasing their motivation in learning. This study strongly recommends the implementation of gamification on GeoGebra to facilitate mathematics learning at the primary level especially in geometry.

Introduction

According to Clough [2] (cited in Kursus Asas Program Pemulihan Khas (Special Remedial Program)) [8] remedial students refers to those who are weak in reasoning, have less ability in making decision or conclusion and lack understanding of abstract items. Remedial learners also known as slow learners have below average skills and slower learning progress than the norm for their age. This kind of students needs more interesting lesson or “hands on” activity in learning mathematics, for example games to increase their motivation and achievement. Nowadays, the world is adopting information and communications technology (ICT) especially in daily life. Therefore, a study of gamification by using Dynamic Geometry Software (DGS) for remedial pupils in primary mathematics is presented in this paper. We examine the pupils' motivation on using gamification with *GeoGebra* through mathematics lesson.

Literature review

Remedial pupils refer to those children who fail to understand the lesson and they might have high, medium or lower intelligence capability (Sharifah, [15]). However, mentally disabled pupils are not included in the category of remedial pupils. Remedial lessons focus on pupils who are unable to master the basic skills of reading, writing and counting at the proper level. According to Tella [16], students who have higher motivation are able to perform better academically than the lower motivated students. Besides, Johnson [7] stated that students' motivation is highly correlated with their academic achievement. MacMillan [10] concluded that slow learners are pupils who performed poorly in school but categorized in special education because their intelligence test scores are above score 70.

In recent years, several studies have focused on digital game-based learning (DGBL). For example, Dickey [3] reported that DGBL approach has positive effect on pupils' learning motivation. Prensky [11] was focused on DGBL. In his opinion, digital games which are normally regarded as a form of entertainment, are an effective tool for engaging students in learning activities. Meanwhile, Moreno [14] stated that computer games are also effective in improving mathematics learning and students' motivation. Kuo [9] also affirmed that digital games could provide a suitable and interesting learning environment able to attract interest in learning mathematics. Chun [1] reported that digital games are able to attract attention and foster higher motivation within the learning group.

Dogan [4] found that technology tools used in teaching and learning are highly effective on students' achievement to gain better understanding and enhance motivation for learning mathematics. Technology is important in mathematics teaching and learning where it can extremely influence the mathematics taught and increase student learning, according to the NCTM [13]. Besides, McGuffey [12] said that DGS such as *GeoGebra* allows pupils to manipulate and produce graphics easily as needed by using the simple tools provided. The game board may become messy if played on a blackboard or paper and pencil, whereas *GeoGebra* allows pupils or teachers to reflect or recheck the mistake they had made. It will also place the pupils in a student-centered learning environment because all of the answers have been set. Furner and Daigle [5] agreed that children should know whether the software used in learning mathematics is effective to them or not besides being observed by teachers when using DGS.

In this paper, we attempt to find out the effect of remedial pupils' motivation in learning mathematics by using gamification on DGS. The researcher strongly sees the need for a study that will be analyzing mathematics understanding using gamification on *GeoGebra*. Without high motivation and confidence, success in learning will not be achieved.

The study

The study reported in this paper examined the lessons of four remedial pupils participating in the learning progress of gamification on *GeoGebra* with the topic of two-dimensional (2D) shapes. Two lessons were involved using two related *GeoGebra* shapes game with teacher's guidance. The three research questions that guided the study were:

1. Do the students- centered activities games encourage pupils in learning mathematics?
2. What is the pupils' perception in learning mathematics by using *GeoGebra*?
3. What is the pupils' perception by using gamification on *GeoGebra* in learning the topic of 2D shapes?

Participants

The participants of the study were one teacher and four remedial pupils. These four remedial pupils were taught in two different lessons by using gamification on *GeoGebra* on topic of 2D shapes. The participants consisted of two year three boys and two year three girls.

Procedure

The pupils were asked to solve two puzzles in separate lessons as in the following:

LESSON	1 “Chinese Match Puzzle 1”	2 “5-Pieces Puzzle”
PROCEDURE	<ol style="list-style-type: none"> 1. Teacher shows some shape to the pupils. 2. Pupils were guided to name the shapes and understand the concept. 3. Teacher demonstrates a test game to the pupils. 4. Pupils start involved in the activity by giving time to repeat the activity. 5. Pupils explain to teacher based on their answer. 	<ol style="list-style-type: none"> 1. Teacher revised previous lesson. 2. Pupils understand the properties of shapes. 3. Teacher demonstrates the test game to pupils. 4. Pupils involved in the test game. 5. Pupils were guided to explain about the properties of the shape based on their puzzle.

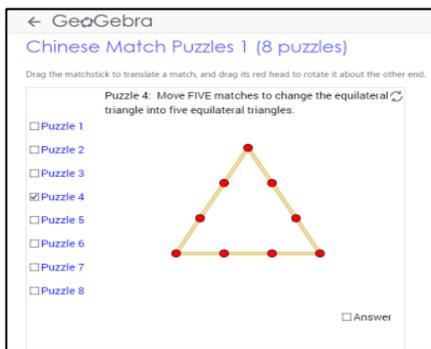


Figure 1. Chinese Match Puzzle 1

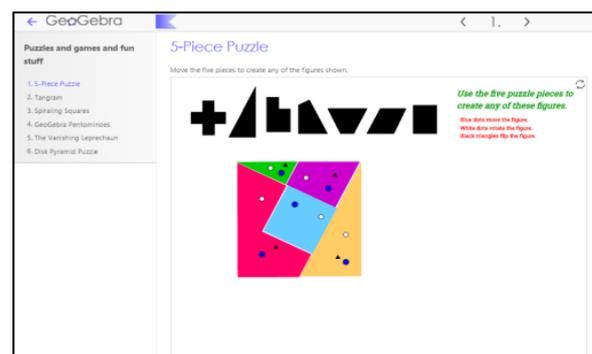


Figure 2. 5-Pieces Puzzle

Data and analysis

The data were collected through observation in two lessons and questionnaire on pupils’ perception in using gamification on *GeoGebra*. Observation had been made by teacher involved in both lessons through video capturing and observation of pupils’ responses while learning topic of 2D shapes in using gamification on *GeoGebra*. The coding of observation on both lessons was carried out as follows.

Lesson 1

In the first lesson, observation had made while remedial pupils were solving the “Chinese Match Puzzle 1” on *GeoGebra*. The observation had been recorded. In viewing the video recording, we focused on pupils’ reaction, motivation and interest during usage of the “Chinese Match Puzzle 1” on *GeoGebra*.

At the beginning of lesson 1, the pupils were sitting down and waiting for teacher to start teaching. When teacher announced that the tool to be used for the lesson is computer, the pupils started to ask question such as “what we are going to learn today”. When teacher was telling the rules and explaining on 2D shapes, pupils were paying attention during the lesson and eager to try. When

Table 2. Frequency of pupils' perception in using gamification on GeoGebra (After lesson)

Respondents	Gamification on <i>GeoGebra</i>														
	Part A Presentation (DGS) :					Part B Application (DGS)					Part C Effectiveness of program				
	Q 1	Q 2	Q 3	Q 4	Q 5	Q 1	Q 2	Q 3	Q 4	Q 5	Q 1	Q 2	Q 3	Q 4	Q 5
1	3	3	3	3	3	3	2	3	3	2	3	3	3	3	3
2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
3	3	3	3	3	3	3	3	3	3	2	3	3	3	3	3
4	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3

Scale: 1 = Disagree, 2 = Agree, 3 = Strongly Agree

Results and discussion

In this section, the findings of this study were presented and completely answer the three research questions that guided the study.

Question 1: Do the student-centered activities games encourage pupils in learning mathematics?

From the data collected and analysis made, the coding of observation shows that remedial pupils were feeling excited when teacher announced they would be using the computer in learning mathematics during the first lesson conducted. This shows that the student were more interested in using computer to study compared to traditional learning methods. Besides, the coding through observation and video recording also illustrated how pupils participate actively in doing activities and learning mathematics with *GeoGebra*. During the beginning of lesson 2, the pupils could not wait to know the tool that will be used by teacher in teaching and learning. Based on the observation, it answered question 1 which agree that students-centered activities games able to encourage pupils in learning mathematics.

Question 2: What is the pupils' perception in learning mathematics by using GeoGebra?

Table 3 shows the percentages of pupils' perception in using *GeoGebra* during the teaching and learning session. From the table it is apparent that pupils prefer to learn mathematics by using *GeoGebra*. The percentage of pupils' perception in using gamification on *GeoGebra* is 100% compared to the percentages before they used gamification concept on *GeoGebra* to learn mathematics. Therefore, they do feel that using *GeoGebra* could increase their motivation and interest in learning mathematics. Besides, they also agreed that they can understand and answer the questions easily by using *GeoGebra* because they can repeat the activities unlimitedly until they master the skills.

Table 3. Percentages of pupils' perception in using gamification on GeoGebra

Gamification on <i>GeoGebra</i>	Before lesson			After lesson		
	1	2	3	1	2	3
A. Presentation (DGS)	(15) 75%	(5) 25%	(0) 0%	(0) 0%	(0) 0%	(20) 100%
B. Application (DGS)	(20) 100%	(0) 0%	(0) 0%	(0) 0%	(3) 15%	(17) 85%
C. Effectiveness of program	(20) 100%	(0) 0%	(0) 0%	(0) 0%	(0) 0%	(20) 100%

Question 3: What is the pupils' perception by using gamification on GeoGebra in learning the topic of 2D shapes?

From the analysis based on observation and pupils' perception questionnaire, it is reasonable believe that the remedial pupils enjoy using gamification concept on *GeoGebra* during the teaching and learning session of 2D shapes. Meanwhile, the pupils also show their interest and the spirit that do not give up easily while doing hands on game on *GeoGebra*. When they faced difficulties, they were willing to get help from teacher automatically. They also responded to teacher with hope to have more such kind of activity in future lessons.

From the observation during the lessons conducted by researcher, pupils were unable to answer the questions asked by the researcher before using the method of gamification with *GeoGebra*. Pupils were discussing but they could not answer the questions even though it was taught in class. After the intervention was given, the pupils showed more interest in the lesson. Subsequently, they were able to answer the questions after some guidance provided by the teacher in the first lesson.

The pupils were given some time to repeat the task with guidance from the teacher. Next, teacher provided some explanation and demonstration to students. In the first lesson, pupils were required to move five matches to form five equivalent triangles. Pupils attempted to explain the task based on the questions asked by teacher.

- Observer : How many triangles are there before moving the five matches?
 Yuen Yi : One
 Observer : How about now?
 Yuen Yi : Five
 Observer : Good. So, can you tell me what is triangle?
 Yuen Yi : [She draws a triangle on the whiteboard]
 Observer : It's nice. How many sides does a triangle have?
 Yuen Yi : Three
 Observer : How do you know that? Can you explain?
 Yuen Yi : [She pointed on the triangle and count the sides of a triangle]
 Observer : Do you feel fun in learning shapes by using computer?
 Yuen Yi : Yes. Can we continue the using the computer?

From the results described above, we conclude that even though the remedial pupils need teacher's guidance in completing the task, but they do show their effort and understanding in learning shapes.

During the second lesson, pupils showed higher achievement after using gamification on *GeoGebra* in learning 2D shapes. They manage to use *GeoGebra* in answering some of the questions

individually. Pupils explained the properties of the shapes on the test. This achievement can be as described in the following excerpt in second lesson.

- Observer : Can you show me the shapes with four sides?
Ze Yee : [He pointed at the shapes with four sides correctly]
Observer : Do you know what is the name of four equivalent sides shape?
Ze Yee : Square.
Observer : Good. So, can you draw a rectangle?
Ze Yee : [He draws a rectangle on the whiteboard]
Observer : It's nice. What is the different between square and rectangle?
Ze Yee : Both have four sides. Square has same sides while rectangle has different sides.
Observer : You prefer to use computer or draw on whiteboard in learning shapes?
Ze Yee : Computer.
Observer : Why?
Ze Yee : It's fun.

This concluded that the pupils understand the 2D shapes topic by using gamification with *GeoGebra* method better rather than traditional learning.

Conclusion

The study shows that both games on *GeoGebra* have been merged into learning lessons among remedial pupils. This study was focused on the remedial pupils' perception and motivation in learning mathematics by using gamification concept on *GeoGebra* compared to traditional learning lessons. Based on the two *GeoGebra* games included in both lessons, we concluded that remedial pupils' perception on learning using gamification on *GeoGebra* and their motivation in learning mathematics through the observation and questionnaires given. As a conclusion based on the questionnaire given before using gamification on *GeoGebra*, remedial pupils were lacking motivation in learning mathematics because they were not confident, short of interest and felt bored. Through the observation made within these two lessons, teacher noticed that the remedial pupils are having higher motivation in learning mathematics and do not easily give up when they fail to complete the games on *GeoGebra*. We suggest that more suitable games be created based on the topic needed and study on teachers' perception in using gamification on DGS be carried out to guarantee a suitable tool and syllabus will be created. Yien, Hung, Hwang, and Lin [17] conducted a quantitative study to investigate the effect of DGBL on students' knowledge of nutrition, attitude, and habits via computer games. In their study, they found a significant difference in achievement between the experimental group and the control group. Many researchers who used DGBL in learning receive positive results on remedial pupils' learning motivation and achievement. Hussain and colleagues [6] in their study also mention that the lack of good quality games especially for remedial pupils in mathematics has reduced the potential of DGBL.

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