Analysis of elementary school students’ mastery in math instruction based on arithmetic gamification

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Abstract. This research is motivated by the importance of multiplication operation ability for elementary school students. This research attempt to analyze the students’ achievement of elementary school students in math instruction based on arithmetic gamification. The research method used is mixed method research and the participants of this research are the 3rd grades of elementary school students in Purwakarta, Indonesia. The results of this study indicate that there is an improvement number of student’s elementary school mastery after applying arithmetic games in the medium category, and all students are engaged emotionally learning math with the game. So it’s a good idea to promote the gamification on arithmetic and other subjects in maths and also technology as a future research plan.

1. Introduction

Through math education, everyone could masteries the 21st century skills, such as critical thinking, creative thinking, problem solving and communication skills [1]. There are not many Indonesian-published math books that present the exercise in the form of context, consequently the mathematics feels abstract and difficult to learn. It is also explaining that mathematics is difficult because of the student himself. Many parents tell their own children that mathematics is a difficult lesson, so children have an understanding that math is a scary subject, so it tends to be avoided [2]. Highly math-anxious individuals are characterized by a strong tendency to avoid math, which ultimately undercuts their math competence and forecloses important career paths [3]. In fact, mathematics its self cannot be blamed entirely, because there are many other things that make the process of mathematical education less than the maximum, so that math is considered difficult by students. Some of those include lack of exercise questions as well as maximizing the use of various methods, media and other things. The interviews result to a few teachers in some elementary schools in Purwakarta, indicate that the difficulties faced by students in learning mathematics is their difficulty in studying the arithmetic operations, especially multiplication. In fact, multiplication is a very important concept to learn other mathematical concepts. One alternative solution is to apply the game of mathematics or called gamification. To mastering arithmetic, there are three stages namely, the concept of understanding the concept, memorize basic facts multiplication and understand the calculation algorithm [4].

Few reports about gamification theory have defined as the practice of using game design elements, game mechanics and game thinking in non-game activities to motivate participants, especially the math
class [5-8]. Other empirical studies report comparative result on gamification against another learning method [9-11]. The gap between the potential of the gamification implementation in arithmetic is rise because the preparation stage of memorizing the basic facts of multiplication can be done by stimulating students to explore the various combinations of the basic facts [4], and this study is a report of empirical studies on arithmetic gamification, because there were no empirical results of gamification on elementary school students, especially in arithmetic.

This study will describe the result of large-scale testing of implementation arithmetic games called “beemmath” and “kurtacil” in some elementary school, the effect and students’ perception. “Beemmath” and “Kurtacil” is a fun and fantastic game that emphasizes fun and extraordinary elements in acquiring mathematical education information. “Beemmath” game is a game that is adapted from one of the quizzes often seen on television. “Beemmath” so called because it uses a honeycomb pattern as a math game media to determine the game map and determine the winner. “Beemath” games will attempt to improve the ability of the elementary school students because the questions will be about multiplication that can be implemented in high or low grade. The game is relatively easy to implement and requires simple tools. The game can be done with 2 people plus 1 person as a judge. some tools needed are 1. Two dice of six, eight or ten and a combination for the low grade. For high grade, the dice can be increased to twenty. 2. A honeycomb game map to be played by 2 people; 3. Different color markers 2 pieces [9]. Like “beemmath” game, “kurtacil” game is also aimed at students' abilities in elementary school. But this game is not only multiplication operations practice, but also with addition and subtraction operations. The word “kurtacil” is taken from the word subtract from the smallest addition. This game is only played by two people without the help of the judges. The results of the game can be directly submitted to the teacher. Some tools and materials to carry out this game are as follows: 1. Two dice of six, eight or ten and a combination for the low grade, for the high grade the dice can be increased to twenty; 2. “kurtacil” game card and a pencil [12].

2. Research method
This research uses a mixed method research, a research method that combines quantitative and qualitative [10]. In this research, the quantitative data is student mastery learning on the arithmetic multiplication numbers, in the first semester of grade 3 elementary school students who will answer the research question whether there is influence the application of “kurtacil” and “beemmath” game model. Students will be given an initial math skills test, a preliminary test of multiplication and a final test of multiplication capability.

Qualitative data in this research is the data of student learning activities during the application of “kurtacil” and “beemmath” game model on multiplication learning in grade 3 of elementary school. After that, based on student learning outcomes, some students will be randomly selected and interviewed to get data about students' responses and students' perceptions. Interviews with teachers will also be conducted to obtain data about teachers' perceptions of learning that have been done by applying the “kurtacil” and “beemmath” game models.

This research uses quasi-experimental design, pre-test and post-test control group design that involve two groups of subjects. One subject group will be treated by applying the “kurtacil” and “beemmath” game model while the other subjects will use direct instruction [13]. From this design, the effect of a treatment on the dependent variable will be tested by comparing the state of the dependent variable in the experimental group after being subjected to treatment with the control group not subject to treatment. The instrument used in this research paper and pencil test, observation guide and the interview guide.

3. Result and discussion
This research uses some grade 3 elementary school in Purwakarta, West Java, Indonesia which applies “kurtacil” and “beemmath” game model and called as an experiment group. The experiments carried out 3 times. The experimental group and control group consist of three school categories, i.e. public elementary school, general elementary school, and religious-based elementary school. In the experimental group, subjects were treated by applying the “kurtacil” and “beemmath” game models
while and the other subjects would use direct instruction. From this design, the effect of a treatment on the dependent variable will be tested by comparing the state of the dependent variable in the experimental group after being subjected to treatment with a control group not subject to treatment. Students score in arithmetic multiplication is shown by table 1.

### Table 1. Students arithmetic multiplication score after 3 times treatment.

| Xa No | Score Pre | Score Post | Xb No | Score Pre | Score Post | Xc No | Score Pre | Score Post | Ca No | Score Pre | Score Post | Cb No | Score Pre | Score Post | Cc No | Score Pre | Score Post |
|-------|-----------|------------|-------|-----------|------------|-------|-----------|------------|-------|-----------|------------|-------|-----------|------------|-------|-----------|------------|
| 1     | 15        | 15         | 23    | 6         | 12         | 45    | 13        | 11         | 1     | 14        | 12         | 23    | 15        | 10         | 45    | 15        | 10         |
| 2     | 13        | 15         | 24    | 10        | 15         | 46    | 12        | 14         | 2     | 15        | 15         | 24    | 3         | 14         | 46    | 10        | 15         |
| 3     | 12        | 9          | 25    | 9         | 9          | 47    | 10        | 14         | 3     | 15        | 15         | 25    | 3         | 12         | 47    | 11        | 10         |
| 4     | 13        | 14         | 26    | 6         | 4          | 48    | 14        | 12         | 4     | 15        | 14         | 26    | 4         | 12         | 48    | 11        | 11         |
| 5     | 6         | 3          | 27    | 7         | 11         | 49    | 13        | 15         | 5     | 15        | 13         | 27    | 8         | 13         | 49    | 11        | 12         |
| 6     | 7         | 9          | 28    | 4         | 8          | 50    | 13        | 14         | 6     | 11        | 15         | 28    | 5         | 15         | 50    | 9         | 11         |
| 7     | 5         | 11         | 29    | 7         | 12         | 51    | 13        | 12         | 7     | 11        | 10         | 29    | 11        | 13         | 51    | 9         | 6          |
| 8     | 5         | 8          | 30    | 15        | 15         | 52    | 15        | 12         | 8     | 11        | 10         | 30    | 14        | 13         | 52    | 7         | 6          |
| 9     | 3         | 13         | 31    | 5         | 10         | 53    | 13        | 11         | 9     | 5         | 12         | 31    | 11        | 11         | 53    | 14        | 13         |
| 10    | 9         | 12         | 32    | 1         | 9          | 54    | 15        | 13         | 10    | 7         | 12         | 32    | 14        | 15         | 54    | 14        | 15         |
| 11    | 11        | 13         | 33    | 2         | 13         | 55    | 10        | 12         | 11    | 5         | 6          | 33    | 15        | 15         | 55    | 15        | 15         |
| 12    | 6         | 12         | 34    | 10        | 13         | 56    | 11        | 12         | 12    | 5         | 7          | 34    | 13        | 14         | 56    | 15        | 15         |
| 13    | 9         | 14         | 35    | 8         | 11         | 57    | 9         | 11         | 13    | 10        | 12         | 35    | 3         | 12         | 57    | 15        | 15         |
| 14    | 8         | 11         | 36    | 11        | 13         | 58    | 15        | 12         | 14    | 4         | 5          | 36    | 4         | 12         | 58    | 11        | 9          |
| 15    | 7         | 12         | 37    | 11        | 11         | 59    | 13        | 15         | 15    | 4         | 8          | 37    | 8         | 13         | 59    | 10        | 15         |
| 16    | 3         | 15         | 38    | 10        | 13         | 60    | 11        | 8          | 16    | 8         | 14         | 38    | 5         | 15         | 60    | 4         | 4          |
| 17    | 3         | 13         | 39    | 9         | 14         | 61    | 14        | 12         | 17    | 7         | 9          | 39    | 11        | 13         | 61    | 9         | 3          |
| 18    | 8         | 12         | 40    | 7         | 13         | 62    | 7         | 5          | 18    | 11        | 13         | 40    | 14        | 13         | 62    | 6         | 8          |
| 19    | 8         | 14         | 41    | 11        | 14         | 63    | 12        | 11         | 19    | 10        | 14         | 41    | 13        | 9          |
| 20    | 9         | 14         | 42    | 15        | 12         | 64    | 8         | 13         | 20    | 10        | 9          | 42    | 15        | 15         |
| 21    | 7         | 11         | 43    | 15        | 11         | 65    | 11        | 8          | 21    | 6         | 13         | 43    | 15        | 15         |
| 22    | 14        | 13         | 44    | 13        | 15         | 66    | 6         | 9          | 22    | 8         | 9          | 44    | 11        | 10         |

Max. Score = 15, X = Experiments, C = Control

Based on table 1, there is actually no difference average score of multiplication ability among students in the experimental group with the students in the control group. The influence of the game only gives a relationship of 11.8% which is a very low category. The test results of the influence of 3 different classes indicate that in class A the “kurtacil” and “beemmath” game model has an impact on students' multiplication ability in grade 3 SD. This influence is slightly larger than the overall R2 score of 7.4% which is a very low category. In class B “kurtacil” and “beemmath” game models also have an effect on students' multiplication ability. This effect is shown by the R2 score of 22.1% which is a very low category. Meanwhile, in class C, this model does not give effect to students' multiplication ability, this is indicated by the score of t count is smaller than t table. Thus the overall impact of regression analysis is likely to be influenced by observational scores in class C.

### Table 2. Number of students mastering in multiplication.

| Group A | Group B | Group C |
|---------|---------|---------|
| Pre     | Post    | pre     | post    |
| 6       | 18      | 6       | 17      |
| Min. Score | 70   |         |         |
Based on the data obtained, the highest influence occurred in class B which is a class in one of the private schools in Purwakarta, West Java, Indonesia. School A is a public school while C school is one of the religious-based schools in Purwakarta. Average grade C score before treatment is higher than 2 other classes. Judging from the average grade C score, it shows a decrease after being treated. It is possible that students prefer other ways of learning in this type of school. The average increase in multiplication scores actually occurred in the state schools, by a margin of almost 4 points. This condition also occurs in public-private primary schools, which may be in the process of daily learning, has characteristics that are quite similar. In general, however, this study has proven that there is a very low effect on experimental classes treated by applying beemath and kurtacil games.

The very low influence in this study is based on the pre-test and post-test scores in the experimental and control groups. Overall, very low effects occur, because the didactic learning steps in the experimental and control groups are almost identical, the difference lies in the exercise step, which is replaced by “beemath” and “kurtacil” games. In class A and B, there is an influence of the game model on multiplication ability, although in very small influence. In class C the influence does not exist, because this class C has a high initial ability score. Both the experimental group and the control group with an average score of more than 75. This is quite higher when compared to classes A and B, each scoring averaged in a range of 46 to 61 alone. This tendency can be attributed to several things, namely that C elementary school is accustomed to innovative learning models compared with A and B elementary school, good facilities and learning resources. In general, the number of students mastering multiplication shows almost doubled increase, from 28 to 53 students or 89%. Table 2 shows that class B has the greatest increase in number. While the smallest increase in the number of students who mastering the multiplication occurs in class C. This result was in line with Yildirim, Michael and Jesse, that student using gamification have a positive impact on student’s achievements [9,10].

From table 2, the result of the interviews to students in class A, B and C show that they enjoy learning multiplication with “beemath” and “kurtacil” games. They say that they feel able to do multiplication, bolder opinion, prefer to learn math with the game and become more spirit in counting multiplication, this is in line with Nicholson and Piaget that game could be meaningful in long-term challenge The most popular game by students is the kurtacil game which has a percentage of more than 60%, while students who like the game “beemath” only about 40% [14,15].

Students' perceptions of multiplication learning with “beemath” and “kurtacil” games based on interview result show that 94% of students when learning by applying “beemath” and “kurtacil” games express the teacher's explanation in explaining the material and game steps clearly and easily understood, 94% students become more focused learning, 83% of students do not get tired of learning mathematics with the game, 100% of students become more understood multiplication, 78% of students when asked to teachers always answered by teachers, 89% of students stated beemath game easy to do, and 100% “kurtacil” is easy to do. All of these show that games can be engaging and that games can be instructive and the game makes the students engage emotionally in line that the games in the learning environment make the students' fun or pleasure [5], their motivation also increased as [10].

Enhancement of students' multiplication skills in elementary school with the application of “beemath” and “kurtacil” games model is measured by calculating the N-gain score. Based on the data obtained, the N-gain recapitulation in the experimental and control groups is shown in table 3. From the table, it was found that Class A and B in the experimental group had an increase in the mid category. Gamification is an effort to make the student learn in their age. In line with this, students at the elementary school is in the concrete operational stage, and very fond of the game, in the concrete operations stage the students operate objects, and not yet on verbally expressed hypotheses. Example,
there are the operations of classification, ordering, the construction of the idea of number, spatial and
temporal operations, and all the fundamental operations of the elementary logic of classes and relations,
of elementary mathematics, of elementary geometry, and even of elementary physics [16]. The game
will make students relax, and feel happy, did not feel forced and afraid, even though they are in the
middle of math education.

4. Conclusion
This research is a medium scale test, that is applying the game model in some variety of school. Although
overall there is no influence of the application of “beemmath” and “kurtacil” game model to the students'
multiplication ability, however, from the completeness there is an improvement of student’s
multiplication ability by 89%. The religion-based schools that are the subject of this research do have
good initial math skills, have good learning support facilities and access to good learning resources or
we can say that they have a better economic level. So, there is no clear difference in learning outcomes
by using the game model in this class.

Contrary, in the other two classes, which are public and private schools, although very low, there is
an influence and an improvement number of students in mastering multiplication arithmetic. This result
was in line with [9,17] that gaming in cooperative goal structure was most effective in promoting
positive math attitudes while classroom goal structure for gaming had no significant impact on students'
math test performance. It was also found that student’s motivation is increased as [9,10]. Students’
responses and perceptions in learning with “beemmath” and “kurtacil” games model in arithmetic
multiplication learning in grade 3 are very good and positive. They are engaged emotionally to with
“beemmath” and “kurtacil” games, and the most popular game was the kurtacil game. Future research
will be directed to the development of more effective games, that can be played anytime and anywhere
using a mobile device, based on current students who are the Y, Z generation.

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