GeMA-ICT Learning Effectiveness in Improving Student Mathematical Ability

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Abstract: This study examines and measures the effectiveness of using GeMA-ICT learning methods (Games, Manipulatives, and Activities with Information and Communication Technologies) on the students' mathematical abilities. GeMA-ICT is a new method that resulted from the theoretical studies of the Mathematics Education Study Program UHAMKA research team. Mathematics has abstract objects such as abstract facts, abstract concepts, abstract operations, and abstract principles. The abstract objects in mathematics education sought to be easily understood by students, by presenting them through concrete objects, props math, math games and math activities supported by the use of ICTs. Props, games, and activities developed with the help of ICTs are a blend of media and learning methods that can visualize math concepts. A set of concrete objects are intentionally drafted, designed, manufactured, assembled, and used for instilling or developing concepts or principles in mathematics. With GeMA-ICT methods, things that can be presented in the form of abstract models such as concrete objects can be viewed, held and manipulated so that they can be easily understood. In addition to presenting math games, learning math is made fun for students and learning activities are turned into a process of investigation and exploration of further mathematical concepts.

Keywords: GeMA-ICT, props math, math games, math activities

1. Introduction

Extant research has shown that effective learning seldom happens in a scenario where the teacher dominates the process and reduces the students to passive participants. Whereas learning ought to be made easy for students, lots of teachers are still making it difficult for them because they do not reinvent their classroom procedures according to the patterns of modern teaching approaches, Classroom activities such as, "one-way lectures" and "take-home-assignments" only teach students to perform certain symbolic procedures as well as to work but not to think. This is what characterizes most mathematics classrooms – students are often confined to a scenario where they simply watch the teacher solve mathematical problems on board and at the end of the class they would be given assignments to take home and solve them in worksheets according to the pattern that the teacher used, (Turmudi, 2008).

Another characteristic of the traditional teaching approach is that teachers emphasize on curriculum attainment targets rather than targeting at mastery of the material. Many math teachers teach by simply following routines that are critically ineffective. This eventually wears them out because the process is not only tedious to the teacher but also damaging to students' interest (Sobel and Maletsky, 2004). Furthermore, in the traditional classroom setting, teachers tend to use chalk and talk method often more than not. This was caused by several possibilities: 1) schools already have props but are not usin them optimally; 2) school do not have props; 3) school have had adequate props but are not good enough (Asyhadi, 2005).

To reinvent the current classroom scenario that still retains the traditional characteristics, and enhance the quality of national education; research must focus on teachers and educational facilities and infrastructure. Learning in the traditional classroom setting does not give room for maximal innovation and creativity and it hinders the opportunity of using a wide variety of methods and media. As a result, learners gain minimal knowledge little understanding of the content of the lessons. Hence, the learning process becomes unattractive and weakening to the national education standards. Adding up all these together, the standard of the competence of graduates becomes significantly undermined. Hence, there is need to test pilot the usage of contextual and humanistic learning approaches in today's mathematics classrooms. Accordingly, the attention of governments and experts of mathematics education in many countries is quite crucial at this point in time, so as to improve the mathematical ability of students and equally champion gigantic efforts for overcoming students' passiveness in mathematics classrooms.

Results in NAEP study show that students are still having difficulties when faced with problems that require reasoning and problem-solving abilities. Mathematics learning of the present day has not been able to develop students' mathematical problem solving abilities optimally. This causes the learning conditions of students to be only able to resolve problems only in accordance with the examples given by the teacher. But when students are given anther problem that is similar but not the same as the examples once given, they find it difficult or even impossible to handle. It was observed in NAEP study that the success rate of students in solving problems dropped dramatically when the context is replaced with things that are not known to the students (Suherman et al, 2003).

However, one of the new offers that can activate students' learning in today's Mathematics classrooms is learning with GeMA-ICT (Games, Manipulatives, and Activities with Information and Communications Technologies). This lesson allows students to be actively involved through hands-on activity. GeMA-ICT is an emphasis on the learning activity of students in the manipulation of concrete objects by exploiting the use of math games, math props, and activities with the help of ICTs. GeMA-ICT encourages students to learn facts, skills, concepts and theories through manipulative activities with concrete objects, models, props, or math games. GeMA-ICT can increase the desire to learn; enhance learning by doing; and enhance the application of scientific problem solving through making analyses and evaluations. GeMA-ICT insists on ensuring that mathematical principles are found, generalized, and proven. This learning approach takes off the abstract nature of mathematics, making it interesting through the integration of games and a variety of other ICT activities.

In this approach, students' thinking phases are made concrete and real, so as to allow for the execution of visual-kinesthetic activities a vriety of ICT tools. On the whole, GeMA-ICT is a good option for overcoming the dull routine of learning in Maths classrooms. It is outrightly appropriate learning for enhancing students' mathematical abilities. Therefore, the purpose of this study is to determine the differences that are likely to be found in mathematics learning outcomes of students using GeMA-ICT method and students using expository method.

2. Literature

2.1 GeMA-ICT

GeMA-ICT is an abbreviation for Games, Manipulatives, and Activities with Information and Communications Technologies. Author deliberately adopted GeMA-ICT in order to obtain the equivalent word that can represent the learning activities of students who will be using the games, props, and math activities with ICTs.

When referring to the percentage of the amount that can be remembered, GeMA is a very important lesson. Johnson and Rising in Ruseffendi (2006) posited that, "learners can remember about a fifth of the heard, half of which is seen, and three-quarters of the done". But in learning Mathematics, the manipulation of concrete objects is very important; yet in most cases the concrete objects used are ordinary local materials.

For learning to be more meaningful teachers should as much as possible avoid dominating the process. Literature has shown that in a teacher dominated classroom scenario, learning tend to be target-oriented-mastery in nature, and such learning has only proved successful in short term given competitions, while in the long run it doesn't provide the child with the desired problem solving ability.

Abstract mathematical objects have facts, concepts, principles and principles of operation, which are as well abstract. It seems that students do easily come to grasp with lessons that are backed up with an orientation of concrete phenomena more than those that are not.

The works of Piaget, Bruner and Dienes have supported the claim that, manipulation of concrete objects is an important activity in mathematics learning. In GeMA, students solve problems, explore mathematical concepts, formulate and experiment with mathematical principles, and make mathematical discoveries through manipulation of concrete objects that represent abstract mathematical ideas.

GeMA learning follows the principle of learning by observing and doing; and it starts from the concrete to the abstract, as is the case with inductive method. Hence, students learn the objects and then generalize while ignoring the special nature of mathematical abstraction. It can attract learners to abstract mathematics. According to Ernest in Turmudi (2008) that learning mathematics is first and foremost is active, with students learning through games, activities, investigations, projects, discussion, exploration, and discovery.

Students can learn facts, skills, concepts, postulates, or theories through manipulating concrete objects, models, props, or math games. Hence, GeMA can increase students' desire to learn, since it is based on the principle of learning by doing; and it also gives room for the students to appreciate and apply the scientific method of problem solving. However, application of learning aids such as laboratory equipment and other media becomes necessary for the implementation of learning with GeMA. But while the design of learning outside the classroom is directed to how students can play while learning, GeMA can be operationalized through the implementation of games, props, and math activities.

2.2 Math Games

Basically the students would love the games and puzzles, because play is indeed a world of children (Turmudi, 2008). Imam Al-Ghazali said, "Playing around for a child is something that is very important but banning him from playing around will turn him off and disturb his sense of belonging, intelligence and general rhythm of life". Children will find it easier to learn arithmetic by means of handing out apples to them than by abstract examples . Congruently, play is seen as a natural activity in helping the child to gain experiences, develop creativity and determination to succeed.

If a mathematical concept is presented through play, the understanding of the concept is expected to be steady, because learning in this way is in a natural pattern, which is in accordance with the child's instincts. Hence, the learning process is a psychological process, not a logical process. Therefore, the patterns should not be mere series of knowledge that have been previously defined in form of a mechanical process; but rather, through play, the students construct their mathematical patterns (Hudoyo, 1985).

Math game is a fun activity that can support the achievement of learning goals in mathematics cognitive, affective, and psychomotor domains. Math games help students to memorize basic facts, find the arithmetic operations and improve numeracy skills, as well as gain more understanding and problem solving ability (Ruseffendi, 2006).

Learning mathematics by games and puzzles was also emphasized by Turmudi (2008), as an approach for motivating and giving fun to both students and teachers alike in the learning process. This is important because games and puzzles have been widely recognized as a way of inspiring students to mathematical literacy. Ernest in Turmudi (2008) claims that games teach math effectively due to: 1) Provision of reinforcement and skills practice, 2) Provision of motivation, 3) Assistance, acquisition and development of mathematical concepts, and 4) Development of problem-solving strategies. Posamentier and Stepelman in Turmudi (2008) presented an analogy between game strategy problems solving strategy in the following table:

Table 1: The Comparison of Games Strategy and Problem Solving

Games Strategy	***No***	***Problem Solving Strategy***
Read the rules	1	Read the rules
Understand the rules	2	What is given and what to look for?
Develop a plan	3	Write the equation
Work the plan	4	Solve the equation
If you win, smile; if not, think about why it lost	5	Check the answer

Moerlands and Makkink (2003), reported that the play activity could help resolve the problem of the "unknown" number. Their study revealed improvement in child's learning outcome by 40%, from a mean baseline (2.6) to 3.7. Congruently, results in this study indicate that the learning using games makes abstract problems seem ordinary (Armanto, 2003). Meanwhile Benko & Maher (2006) have reported significant improvemnts in students' oral, written ability and physical representation ability to level 7 after learning through games that use dices.

2.3 Props Mathematics

Props are teaching media that contains or carries the characteristics of the concept being studied. A set of concrete objects are designed, manufactured, assembled, or prepared deliberately to help embed or develop concepts or principles in mathematics. With props, things that can be presented in the form of abstract models such as concrete objects that can be seen, held and distorted are used for teaching, so that lessons taught can be easily understood.

Since the 1950s until the 1970s, research into the use of props in teaching mathematics has been going on, and not less than 20 summaries of such researches have been recorded. Among these is the popular summary of Higgins and Suydam in 1976 (Lithanta, 2009), which among other things concluded as follows: 1) In general, the use of visual aids in the teaching of mathematics was successful or effective in promoting student achievement. 2) Approximately 60% vs 10% of the students sampled showed a convincing success of learning with the props than without. 90% of students that learnt with props recorded yet the same magnitude of 90% in their learning outcomes above those students that did not use props. 3) Manipulation of the visual aids is important for elementary students at all levels. 4) Only a little evidence was found showing that manipulation of props is only manageable at lower learning levels.

Slamet, Soenarto, and Wahidin (2008), reported that the ability to compute and factorize quadratic equations and increase students' learning outcomes becomes easy when lessons are administered with props, AEM (Block al-Khawarizmi). Congruently, studies have shown that learning with games could serve the needs of students at all levels; and even weak students could easily manipulate concrete rectangular objets using their prior knowledge of the broad concept of the rectangle, (Dienes AEM). Hence, a problem is often best solved (understood) by using sketches, folded pieces of papers, pieces of strings, or other simple props available. Invariably, strategic use of props can make the situation real to the students so as to motivate them to learn faster and better. Therefore, manipulation of geometry models can be a way of help the problem solving process as well as an activity for innovation, (Sobel & Maletsky, 2004).

Mathematics learning activities wherever possible involve all the senses of the students, especially hearing, seeing, and touching. In this case props bridge gap between the abstraction process and apprehension. In addition, by using the props, the child can be helped to find a strategy to solve problems. This is done by allowing the child to describe the problem in a simple concrete pattern; construct his or her own knowledge and understanding of the issues for the purpose of develop problem-solving strategies (Triyana, 2004).

2.4 Activities

In learning with games, activites are equated with experiments in a way that present lessons for students to conduct experiments and prove their own experiences and the things they learnt. In this case, students are given the opportunity to experience for themselves, learn on their own, following a process that allows them to observe objects, analyze issues and draw conclusions, (Djamarah and Zain, 2006). Through this practicum process, the students are able to discover facts and truths in the form of conjectures and theorems by themselves.

Learning mathematics through practical applications or hands-on experience is an activity within the framework of the invention and principles of mathematical concepts. The process is helpful in improving students' ability to explore, investigate, and the draw conclusions through physical activity, as well as through mental and emotional engagments, (Krismanto, 2003). For the full geometry of the material abstraction, hands-on mathematics is still a necessary experience for improving students' learnig outcomes.

With the mock objects (models) or concrete objects that are deliberately prepared to further stimulate the minds of students in constructing their own understanding, there are more elements of practical work on learning experiences for students to use the knowledge they gained (according constructivism) and not to solely depend on how their teachers teach math. This is an advocation for a paradigm shift in teaching mathematics.

From the analysis of data from the 1996 NAEP test, two samples of countries involving 15,000 students mentioned that the rate of 8 students whose teachers actively taught through the process of learning activities generated employments in mathematics achievement levels of more than 70% (Crawford, 2001).

Vui (2006-2007) reported that the goal of good practice in teaching mathematics is to help students make meaning of the contents and skills taught in the lessons (what is known) and the process involveds (what is done). Good Practicum must balance between the content and the process of lerning problem solving skills, because the two are entirely different aspects of the knowledges which the students must be equipped with, all their lives. When teachers use manipulative materials in teaching mathematics, they discover that their students are more active in learning. Students enjoy learning mathematics with dynamic models or motions. Teachers must learn how to create new mathematical models of problematic situations and prepare good manipulative materials for students to deal with. Students may also be inspired to build their own questions and activities.

2.5 Using ICTs

Using ICTs in this study refer to the use of Microsoft power point and GeoGebra Software. The use of Microsoft power point should be simplified in a way that will make it a preferred attraction to many. Currently, Microsoft PowerPoint is widely used by teachers in delivering course materials. Most teachers consider the use of Microsoft power point as an effective and efficient tool for practical learning.

In the use of GeoGebra many interesting things can be encountered and difficult mathematical problems such as in calculus lessons are easily resolved with the GeoGebra media software. Hence, apart from calculus problems, other mathematical problems, such as solving line equations, vectors, angles, algebras, geometry and many others can be easily resolved by the use of the GeoGebra media software. In addition, GeoGebra is designed to facilitate its use in an interactive way.

3. Research Method

3.1 Research Instruments

This research was conducted among the 150 Junior High Schools at Kramat Jati, East Jakarta on January 20 until February 4, 2014. This study uses a quasi-experimental design. In a quasi-experimental, the subjects are not taken at random but researchers do accept existing subjects. The use of quasi-experimental research is based on the consideration that there are classes that were not considered previously formed at random grouping of individuals who would disturb the Teaching and Learning Activities at schools.

The population in this study were students of 150 Junior High Schools, that comprised up of 8 eighth grade classes. This research used two classes as a sample, each of which has the same characteristics. The first class was used as an experiment class, and it was taught by using the GeMA-ICT. The other class was used as a control class, and it was taught without using the GeMA-ICT.

Data was drawn from the results of learning mathematics scores amanog 71 students sampled. The research instrument used to measure students' mathematics learning outcomes was desinged with multiple choices questions having four (4) alternative answers. The validity of the instrument was measured using the point biserial correlation formula, by which the instrument earned as much as 20 valid questions. Reliability of the instrument was measured by using the Kuder - Richardson (KR-20) formula, by which the instrument a very high reliability degree of $R_{11} = 0.836 > r_{table} = 0.329$.

3.2 Data Analysis

Students mathematical ability tests were analyzed by using the inferential normality test, homogeneity test and t-test, to see the effectiveness of a given learning GeMA-ICT method.

4. Result

4.1 Student Mathematical Ability

The descriptive statistics research data obtained from the study of mathematics students in the experimental class (i.e. the class taught with GeMA-ICT method) is presented in Table 2 below:

Table 2: Descriptive Statistics of Students Learning Outcomes in Math Experiment Class

Data	Maximum Score	Student Learning Outcomes Math Scores						
		Y_{min}	Y_{max}	$\overline{Y}$	s	s^2	Me	Mod
35	20	9	18	14,74	1,99	3,96	15	15

The descriptive statistics research data obtained from the study of mathematics students in the control class (the class that was taught without using GeMA-ICT method) is presented in Table 3 below:

Table 3: Descriptive Statistics of Student Learning Outcomes Math Control Class

Data	Maximum Score	Student Learning Outcomes Math Scores						
		Y_{min}	Y_{max}	$\overline{Y}$	s	s^2	Me	Mod
36	20	7	17	13,08	2,55	6,48	13	13

4.2 Results of Testing Data Analysis Requirements

Using the Lilliefors test, it was concluded that the experimental and the control class data derived from the sample had a normal distribution.

Using the Fisher test, it was concluded that the samples of the two classes of experimental class taught using GeMA-ICT method and control class taught without using GeMA-ICT method have the same conditions or homogeneous variance.

4.3 Results of Hypothesis Testing

Through the calculation of the average grade, experimental and control classes obtained t = 3.06 and t (0.95; (69)) = 1.67 with a significance level $\alpha = 0.05$ and (df) = 69. Since t = 3.06 > 1.67 = t (0.95; 69). This means the rejection of the research hypothesis H_0 which stated that there are significant differences in mathematics the learning outcomes of students taught with GeMA-ICT method and those taught without using GeMA-ICT method in the 150 Jakarta Junior High Schools.

5. Conclusion

GeMA-ICT methods improve students' mathematics learning outcomes owing to students' usage of manipulative activities, props and games in this study. The process also allows students to discuss with each other in the group. On the whole, the GeMA-ICT method improves students' learning outcomes better than other methods of teaching mathematics.

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