The Implementation of Mathematics Props-based Learning on Geometry Concept

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Abstract. Geometry concept learning for grade VIII of secondary high school is possible to be taught using props, as these props are able to assist students in discovering the concepts and formulas that would be used to solve mathematics problems for better concept mastery. This learning is in accordance with the Indonesian 2013 curriculum where one of the geometry concepts is a circle. Therefore, this study is aimed at examining the mastery of circle concept in students who were taught using the props compared to the students who were taught using the conventional teaching. This study is quasi-experiment implemented in two classes. The first class were taught by using the props and the other class were taught by using conventional teaching in circle topic. The instruments in this study consisted of the circle concept mastery, teacher’s ability to manage the learning, and students’ activity during the learning session. The data were analyzed using Covariance inferential analysis and descriptive analysis. This study reveals that circle concept mastery of the students who were taught using props was higher than those taught using conventional learning. Teacher’s ability to manage to learn with props was within the very good category, and the students’ activity during the learning session was within the very active category. This study recommends that learning using props is one of the learning alternatives that can be adopted by the teacher to teach and increase students’ mastery in circle topic specifically and in general increase students’ mastery of the concept of geometry.

1. Introduction
Mathematics is one of the subjects taught in secondary high school. Mathematics is needed due to its vigorous and clear structure and correlation among its concepts, hence, enable those who learn math to become skilled in thinking rationally [1]. Everybody needs to learn math as it can lead people to think clearly and logically, and solve daily problems, as well as providing means for recognizing relationships patterns and developing creativity and awareness in cultural development [2]. Therefore, mathematics concept mastery is essential.

One of the topics in math taught at secondary high school is geometry. This concept needs to be mastered by the students for them to be able to use mathematics reasoning in solving math problems and other problems in life. Mastery of geometry concept by junior high school students can be taught using props. Props are tools that can help learners to better understand the concept [3]. Props as demonstration kits characterize the concept of the learning material used to demonstrate the topic, hence, the topic can be easily understood by the students⁴. Thus, props are part of teaching materials or tools that can be used by the teacher in teaching concepts or formula to their students, hence, can be easily understood. Props are widely useful for teachers in the learning process.
Props in learning are also useful for students. These props can: (1) help in increasing the students’ knowledge and skills, (2) illustrate and enhance the message or information, and (3) eliminate constraints, and idleness [4]. Thus, props can be used by both teacher and students in the learning process, including in mathematics learning process. Sukayati argues that all things used in mathematics learning can be classified as math props [5]. Mathematics props are tools made by the factory, teachers, or things and used by teachers and students in mathematics learning.

One of the sub-concepts in geometry is circle which being taught to grade VIII of secondary school. The circle concept can be explained using the props. The field observation showed that teacher had not been fully involving students in finding its concept and formulas. It is common that teacher in discovering the concepts and formulas generally inform the students what concept that would be studied and write formulas that would be used in resolving problems. As its consequence, student’s mastery of circle concept is less than expected.

The circle concept within the Indonesian 2013 curriculum was evident in 3.6 Kompetensi Dasar (basic competency henceforth called as basic competency or KD). The 3.6 basic competency is aimed at identifying elements, the circumference, and the area of the circle. The 3.7 the primary competency is aimed at determining the correlation of angle, arc, and sector. Each basic competency later defined into competency achievement indicator. Competency achievement indicators for KD 3.6 are: (1) explain the concept, plane, elements, and parts of circle, (2) use the value of phi and the circumference formula in solving the tasks, (3) use the circle formula in solving tasks. Meanwhile, the indicator achievement for KD 3.7 are (1) calculate the center angle and circumferential angle facing the same arc, (2) determine the degree of circumferential angle when it is facing the diameter, (3) ascertain the degree of circumferential angles that are facing the same arc, (4) calculate the length of the arc, area of the sector, circular segment and its problems. These indicators have been developed in a previous study by Abbas [6].

The description of competency achievement indicator of this circle concept can be seen from students’ mastery on this concept. This achievement is predicted to be achieved through implementation of props-based learning. It learning tools developed by the research team in the previous year, which consisted of learning materials, alternative props, and lesson plan based on the 2013 curriculum [7]. Therefore, this present study aims at finding out information on the advantage and acceptance of the developed learning materials. To achieve this objective, the study compares the learning achievement of students from two classes taught using different learning tools.

2. Method
This study was the continuation of the competitive grant funded by the ministry of education and culture of the Republic of Indonesia. The initial year study (in 2013) has developed learning materials, alternative props, and lesson plan based on the 2013 curriculum through research and development method. The research procedure used in the initial year referred to the one developed by Thiagarajan, Semmel, and Semmel which consisted of define, design, develop, and disseminate steps [8]. The initial year research was completed up to limited trial. The second-year research was a dissemination of the initial year result. The research dissemination was conducted in SMPN 10 (Secondary high school, henceforth called as SMP) in Gorontalo city in the second semester of 2013/2014.

2.1 Research Design
This quasi-experiment study used two groups of randomly-selected students taught by using different learning tools. The first group (Grade VIII-2) was taught using props (X₁) and the second group (Grade VIII-3) was taught using the conventional learning (X₂). Students in these two groups were given pretest (O₁) to obtain baseline information on students’ mastery of circular concept, and this study was concluded with posttest (O₂) to get information on the change of students’ ability in circular concept. The design of this study was called randomized pre-test post-test control group design9. The research design is presented in Figure 1 below.
Figure 1. Research Design

| Class          | O₁   | X₁   | O₂   |
|----------------|------|------|------|
| Experiment     | O₁   | X₁   | O₂   |
| Control        | O₁   | X₂   | O₂   |

Note:
- R : Random
- X₁ : class taught using props
- X₂ : class taught using conventional method
- O₁ : pretest
- O₂ : posttest (circular concept mastery)

2.2 Population and Sample
Population in this study was all grade VIII students of SMP Negeri 10 of Gorontalo city for the second semester in 2013/2014 academic year which distributed in four classes. The samples were taken through simple random sampling. Class VIII-2 was taught using props in circular topic, while class VIII-3 was taught using teacher’s conventional method.

2.3 Data Collection Method
Data collection methods were test and non-test. The test was administered to collect the data on students’ mastery in circular concept. This instrument consists of multiple choice test of four choices. The validity of the test item was tested using point biserial correlation coefficient formula, while the reliability of the test was tested using Alpha Cronbach formula. The non-test technique was in the form of observation sheet to collect the data on teacher’s ability to manage the learning which was composed of four-scale statements, 4=very good, 3=good, 2=moderate, and 1= insufficient. Students’ activity during the learning process was also assessed in four-scale statements, 4= highly active, 3= active, 2=moderately active, and 1=less active. The checklist was used as instruments to assess the students and teacher responds.

2.4 Technique of Data Analysis
The technique of data analysis used descriptive and inferential analysis. Descriptive analysis was used to describe the data on observation of teachers and students’ responds during the learning process and categorized them. The inferential statistic was used to analyze the advantage of the developed learning materials based on the achievement of students’ mastery. Statistical analysis utilized in this study was covariance analysis (ANACOVA).

Neter and Wasserman [12] mentioned that two main requirements have to be fulfilled in covariance analysis, namely: (1) regression model between the dependent variable and moderating variable that suits the simple linear correlation in each observed factor, (2) all models are linear. The analysis requirement tests were: (1) linearity test, and (2) homogeneity test. Linearity was tested using the F-Tuna Cocok, while homogeneity of the variance was tested using F-test as follows.

\[ F_0 = \frac{(B - A)/k - 1}{A/(N - 2k)}, \text{ where } A = \text{SST}_X(adj) \text{ and} \]

\[ B = \frac{(SPT)^2}{\text{SST}_X}. \]

3. Results and Discussion
This study consisted of analysis of the result of the research hypothesis, analysis of the data of teacher’s ability to manage the props-based learning, students’ activity during the learning process, and students’ responds toward the learning.
3.1 Research Hypothesis Testing

The hypothesis in this study was that mathematics mastery of those taught using props is higher than those taught using teacher’s conventional ways in circular concept. The tested statistical hypothesis was:

\[ H_0 : \mu_1 \leq \mu_2 \]
\[ H_1 : \mu_1 > \mu_2 \]

Note:

\( \mu_1 \) = average mastery of the circular concept of students taught using props.
\( \mu_2 \) = average mastery of the circular concept of students who were taught using teacher’s conventional ways.

Testing Criteria:

- \( H_0 \) was rejected if \( F_0 \geq F_{\text{critical}} \) in the significance level of \( \alpha \) with a degree of freedom (df) of numerator = \( a - 1 \) and df denominator = \( n - m - a \) (\( m \) = number of covariable), otherwise \( H_0 \) was accepted.

Calculation result using Excel for Windows 2010 software revealed \( F_0 = 18.92 \). The value of \( F_{0.95: 1/56} = 4.02 \). Because \( F_0 = 18.92 > F_{\text{table}} = 4.02 \) then the \( H_0 \) was rejected or that \( H_1 \) was accepted. This means that the average mastery of circular concept on students who were taught using props was higher than those who were taught using teacher’s conventional ways. This finding reveals that props-based learning has more advantages to be used in teaching circular concepts compared to teacher’s conventional ways. This finding supports Heruman’s statement that props can be used to assist students’ critical thinking pattern in basic concepts learning [14].

Students’ mastery of circular concept obtained through students-teacher interaction within the practice using props enables students to master the concept and implement it in problem-solving. Therefore, it was recommended to mathematics teacher to adopt props-based learning in teaching the circular concept and other similar concepts in order to improve students’ mastery of geometric concepts.

3.2 Analysis of Teacher’s Ability to Manage the Learning

Teacher’s ability to manage the props-based learning was observed from: (1) how they deliver the learning objective, (2) correlate with previous learning, (3) encourage students’ interest to learn through events, phenomena, or other problems related to the topic that would be learned, (4) guide students to conduct observation through props in discovering the concept that currently being learned, (5) encourage/guide students to collect relevant information using the props in finding the concept, (6) train students to use props in identifying the problem-solving concept, (7) encourage cooperation/discussion in conducting observation/experiment or in solving the problem, (8) guide students to conclude the result of their observation/problem solving, (9) guide/encourage students to present the result of their problem-solving/experiment, (10) Assist the review of the process/result of the observation/problem solving, (11) guide students who have not accomplish their problem-solving process, (12) guide students to summarize the topic materials, (13) provide training and or remind students to review the materials that they just learned and to read the next materials, and (14) manage time.

Observation of learning process was conducted for eight meetings involving two observers. The average score of the observation was 3.71. This score means that in average teacher’s ability in managing the props-based learning was within the very good category. This finding indicated that teacher was skilled and able to implement props-based learning. Teacher’s ability has strengthened the circular concept of those who were taught using props tools and made it better than students’ mastery of the concept in the classroom where teacher only taught using conventional ways of teaching.

However, on time management aspect, almost all teacher got a low score, which meant that the time allocation planned in lesson plan was not sufficient for its implementation. Therefore, it was recommended for the school principal to put together the five hours slot per week allocated for mathematics subject students into one day and do not separate them into several days as currently
practice [6]. In order to optimize the guidance and assessment of learning process in each student, the teaching should be delivered by a team teaching that consists of three to four mathematics teachers.

3.3 Students’ Activity Analysis
The observed students’ activity aspect during the props-based learning were: (1) listen/pay attention to teacher’s explanation, (2) read/observe the book/students’ activity sheet, (3) work together in a group to discover the concept through props, (4) collaborate within a group to solve the tasks/problems including writing activities that are relevant to learning process (5) discuss/ask questions among students/groups/teacher, (6) state ideas/opinion, (7) give feedback to teacher/friend’s question, (8) work using props, (9) present the observation/experiment/problem-solving result, (10) review the concept discovery process/problem-solving process, and (11) conclude the result of the today’s learning.

Analysis of the data from eight meetings revealed that the average score was 3.70. This means that students’ average participation during props-based learning was very active. This finding indicated that almost all students actively involved in learning process. Students were not tense and were not reluctant to learn. This is in line with Asyhar’s statement that the learning props used by students in the learning process can help them to increase their skill and knowledge; illustrate and enhance the message and information; and eradicate tenseness, obstacles, and reluctance [4].

3.4 Students’ Responds Analysis
The students’ feedback on learning process consisted of: (1) learning components (learning material delivery, practice worksheet, learning material, learning activities within the class, and the way teacher teaches), (2) opportunities during the learning process (conduct observation using the props in discovering the concept and solving the tasks/problems, work using the props, responds toward the teacher’s question/opinion, pose questions to the teachers, and ask questions to friends, (3) ability to use props, ask teacher/friends, respond to teacher/friends’ questions, (4) eager to participate in learning that are similar to ones that they have engaged in, (5) whether the props, the learning materials, and learning activities in class are useful or not, (6) whether it is easy or not to conduct observation with the props in discovering the concept and solving the problems/tasks, work with props, responds to teacher’s opinions/questions, ask questions to teacher, and ask questions to friends, (7) the language that is easy to use both in worksheet and in learning materials.

The analysis on all seven aspects of students’ responds showed that almost all students are happy with the learning components (the delivery of the materials, the worksheet, learning material, learning activities in class, and the way the teacher teach) and students have revealed that they are being taught with new learning components. The learning materials, the worksheet, and the learning activities in class also received useful responses in assisting the students in their learning process. Students were eager to participate in props-based learning for other topics and expected that mathematics learning could be done with their full involvement in discovering the concept, formula, and problem-solving. This finding showed that the developed props-based learning used in circular topic obtained a positive response from students.

4. Conclusion
Based on the results and discussion in this study, it can be concluded that the developed props-based learning can be used by the teacher as one of the alternatives in mathematics teaching, especially in circular concept as this learning was able to make students have a better mastery of the concept. It also made the teacher more skilled in teaching as well as making the students participate happily and actively in the learning process. The teacher could adopt this learning material in developing other teaching materials to optimize the mathematics concept. In maximizing the guidance toward the students during the learning and assessment process, it is recommended that the mathematics teaching is conducted by the team teaching which consists of three to four teachers that work collaboratively. This is to provide more space for teachers in creating and managing the learning that is centered on students. It is also recommended that the five hours slot per week for math subject should not be
divided into several days as currently being practiced, rather, it is integrated into a day learning.

References
[1] N. Abbas. 2006. Correlation between Interest in Teacher Profession, Teacher Innovation, and Training Experience with Mathematics Teachers’ Professionalism in Secondary High School Teacher in Gorontalo Province in 2000. Dissertation, PPs Universitas Negeri Jakarta, Jakarta
[2] M. Cornelius. 1982. Teaching Mathematics. Nichols, New York.
[3] Depdiknas. 2007 Indonesian language Dictionary, Edisi Ketiga. Balai Pustaka, Jakarta
[4] R. Asyhar. 2012. Creativity in Developing Learning Media. Referensi, Jakarta.
[5] S. Sukayati. 2009. Utilization of Mathematics Props in Learning at Elementary School Yogyakarta: PPPPTK Matematika.
[6] Regulation of the Ministry of Education and Culture of the Republic of Indonesia No 68 of 2013 on Basic Framework and Structure of Curriculum in Secondary High School (2013). Depdikbud, Jakarta.
[7] N. Abbas, P. Zakaria. 2013. Development and Implementation of Props-based Math Learning in Secondary High School in Gorontalo Province and Its Influence on Secondary High School Students’ Mathematics Mastery. Initial Year Competitive Grant Report, Lemlit UNG, Gorontalo.
[8] S. Thiagarajan, S. Dorothy, Semmel, I. Melvyn. 1974. Instructional Development for Training Teachers of Exceptional Children. A Source Book. Central for Innovation on Teaching the Handicapped, Bloomington.
[9] D. Ary, L. C. Jacobs, A. Razavieh. 1982. Introduction for Research in Education, Translated by Furchan, Usaha Nasional, Surabaya.
[10] Djaali, P. Muljono. 2008. Assessment in Education, PT Gramedia, Jakarta.
[11] N. Abbas. 2000. Implementation of Problem-Based Learning in Mathematics Learning in Senior High School. Thesis. Universitas Negeri Surabaya, PPs Unesa.
[12] J. Neter, W. Wasserman. 1974. Applied Linear Statistical Models. Richard D. Irwin Inc, USA.
[13] G. A. Ferguson. 1989. Statistical Analysis in Psychology and Education. Sixth Edition, McGraw-Hill International Book Co, Singapore.
[14] Heruman. 2007. Model of Mathematics Education in Elementary School, PT Remaja Rosdakarya, Bandung.