

The Effect of Dynamic Geometry Software Geometer's Sketchpad on Students' Achievement in Topic Circle among Form Two Students

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ABSTRACT

This aim of this study is to identify the effectiveness of the use of Geometer's Sketchpad (GSP) in the teaching of circle among Form Two students. The quasi-experimental study was to investigate the following two aspects, namely the effectiveness of GSP on learning Circle and a survey instrument was used to elicit students' perception on the use of GSP. About 82 students from two classes selected randomly and divided into a treatment group and control group. The results showed that students exposed to the use of GSP obtained significantly better mean test scores compared to the students in the control group which learned in traditional method without any intervention. Therefore, using GSP in teaching and learning the circle properties had improved students understanding. Analysis of the questionnaire was a positive feedback on the use of Geometer's Sketchpad in learning circle. *Metin girmek için burayı tıklayın.*

Keywords: *Geometer's sketchpad, Circle, Mathematical software, Lower secondary*

INTRODUCTION

Mathematics is a core subject in secondary schools and covers many aspects. The content of the syllabus of Mathematics Secondary School Integrated Curriculum (KSSM, 2016) covers the knowledge and skills of three interrelated areas namely, Number, Shape & Space and Relationship & Statistics. According to Owens and Outhred (2006) one of the most important topics in the mathematics curriculum is Geometry because it is a rich source of visualization for arithmetical, algebraic and also statistical concepts. It is imperative for educators to look at ways to enhance the teaching and learning of circle, which is fundamental at the secondary level. Thus, mastery of geometry knowledge should be enhanced from time to time in order to provide the societies to meet the needs of development and establish a developed country (Ojose, 2011).

Geometry is connected to every component in the mathematics curriculum and to a multitude of situations in real life; hence students require better understanding in geometry (Erdogan, Akkaya, & Celebi Akkaya, 2009; Yegambaram & Naidoo, 2010). Many teachers have observed that students have numerous misconceptions about geometry when a teacher discusses a geometry proof problem in class such as lack of background knowledge, reasoning and basic operation mistakes (Lavy & Leron, 2004; Özerem, 2012). Because of the misconceptions, students had difficulties to manipulate and understand circle properties (Prescott, Mitchelmore, & White, 2002). Zanzali and Nam (2000) & Heong (2005) stated that along with these difficulties, Malaysian students' mastery of problem-solving is still low and there is a need for teachers to examine their practices that consists of their choice of teaching methods and instructional activities. A number of researchers have experimented different ways of teaching and found serious shortcomings in

geometry learners: these include incomplete comprehension of the problem and mathematical symbols, and lack of ability in producing proofs based on direct visual elements (Adolphus, 2011; Chazan, 1993; Healy & Hoyles, 2000).

Teaching and learning mathematics traditionally were only taught using the chalk-and-talk method which focused on a concept that did not enable students to obtain a deep understanding of the concepts, gave little involvement in classroom discussions and created difficulties in visualizing the diagram (Brahier, 2016). This supported by Tay and Wonkyi (2018) stating that traditional teaching approach made students difficult to construct, visualize and justify geometrical concepts especially circle theorems. Moreover, this teaching approach focus on students memorizing the computations and lack of importance are given on students thinking and reasoning skills. Hence, teacher dominate the classroom and students be the listener (Mereku, 2010). Lack of participations and communication leads to failure in problem-solving skills and performance. Therefore, computer-based teaching and learning process needed to improve student proficiency in math learning, facilitate and accelerate students' understanding of circle concepts and supply more information and knowledge through the inquiry findings. Computer software used in the teaching and learning process will help students understand and develop concepts and principles of math easily and effectively (Dimakos & Zaranis, 2010). Using appropriate technology can help to improve student's performance and achievement in learning (Jackiw, 2001; Sinclair, 2003). This situation invariably results in students due to experiencing learning of circle as dull, dry and boring instead of fun, enjoyable and valuable. In contrast, students' positive attitude and beliefs toward learning mathematics can be fostered if students find learning circle useful and enjoyable. This will result in greater improvements in their mathematics performance (Ignacio, Nieto, & Barona, 2006).

The National Council of Teachers of Mathematics (NCTM) identified technology as one of the principles for teaching and learning mathematics. Moreover, NCTM recommended technology as a teaching and learning instrument in geometry lessons (NCTM, 2002). According to Meng and Sam (2013) and Guven and Kosa (2008), teachers viewed Geometry's Sketchpad (GSP) as a useful tool in geometry as it provides an environment in which students can explore geometric relationships and make and test conjectures. The features offer opportunities to the student to explore, develop and learn three-dimensional geometry because some measurements such as angle, length and surface area obtained on the screen via the software (Guyen & Kosa, 2008). Geometer's Sketchpad enables students to build exact figures and control them intuitively (Oldknow, Taylor, & Tetlow, 2010). GSP helps students to create mental models for contemplating geometric shapes and their properties. Satterfield (2001) recommended that Geometer's Sketchpad is perfect for agreeable adapting additionally serves educators well as a show apparatus so that if the teacher has a restricted measure of computers, students can still comprehend the visual parts of Geometry.

Though it is encouraging to see that several previous studies have demonstrated positive effects of technology based instructional approach lessons on students' achievement. Therefore, it is the aim of this study focused on the effectiveness of using Geometer's Sketchpad (GSP) among form two circles topics involving subtopic namely in understanding and using the features circle involving symmetry, chords, and arcs. This software, GSP is suitable for this topic because, through this software, students can explore activities such as drawing, measuring angles and length of a circle. This can stimulate their interest to try it; indirectly GSP helps increase students' interest as well as deepen their understanding on the concepts of circle. Moreover, will enable students visualize geometric images in GSP interface and discover properties about circle.

OBJECTIVES AND RESEARCH QUESTIONS

The purpose of this study is identifying effectiveness of using Geometer's Sketchpad for teaching and learning Circle topic among Form Two students. This study aimed at addressing the following research questions:

1. H₀ 1: What is the effectiveness of using GSP on students' understanding of circle as compared to the traditional approach.
2. H₀ 2: What are the students' perceptions about using the Geometers' Sketchpad in the learning of circle?

RESEARCH METHOD

Research Design

A quasi-experimental non-equivalent pretest and posttest design study was carried out using geometer activities based on GSP software to improve Form Two student's performance in circle topic.

Participants

Participants for this study were Form Two students selected from a school in Klang. Two intact classes consisting of 82 students in total were selected for this study. One of the classes was assigned as an experimental group while the other became the control. The experimental group consisted of 40 students while the control group consisted of 42 students. The researcher taught both the groups.

Data Collection Tool

Pre and post-test was used to obtain data. Pre and post-test consists of multiple-choice questions covering the topics and structure form two circles by topics taught according to the appropriate level with students (easy, medium and hard). Question test consists of 20 questions divided into subtopics identify and draw parts of circle, understand and solve concepts of circumference, arc, area and sector of circle. The time allotted was 45 minutes. All respondents had been given the same test paper. The design of the pre-test and post using two measurements (measurements of the same) to the independent variables (learning circle) that before and after the independent variable (Software Geometer's Sketchpad) manipulated. With this instrument, the researcher can identify and make comparisons between the two groups thus determining whether there is any impact in learning mathematics using GSP.

The researchers utilized the instrument from Christensen and Stephens (2003) and Noraini Idris et al. (2003) about students' perceptions towards the usage of Geometer's Sketchpad software. The instruments were adopted into this research and distributed among students in the experimental group. The questionnaire consists of 4 sections, namely:

- i. students' perceptions on the usage of Geometer's Sketchpad,
- ii. students' perceptions on how Geometer's Sketchpad helps understanding,
- iii. students' perception on their abilities to communicate when using Geometer's Sketchpad
- iv. students' perception on their attitudes towards geometry, when using Geometer's Sketchpad.

As for the scale used, the questionnaire adopted a five-point Likert scale format to assess students' responses for each related section. (1-Strongly Disagree, 2-Disagree, 3-Neutral, 4-Agree, 5-Strongly Agree).

Collection of Data

This design consists of two groups of respondents, one as a treatment group and the other as the control group. Meanwhile, a pretest provides a measure on some attribute or characteristic assessed for students in both groups before they receive an intervention. A posttest is a measure on some attribute or characteristic that is assessed for students after an intervention. The comparison of pretest and posttests determined the effectiveness of the GSP. This design was chosen because it is suitable for assessing changes in knowledge, awareness, skills, attitudes, beliefs and behavior of respondents (Davis, 2002). The study showed that the selection of the design of "pre-post" brings advantages such as it takes less time, is less intrusive and for self change report, avoids protest sensitivity and response shift bias protest that result from overestimation or underestimation (Creswell, 2002; Klatt & Taylor-Powell, 2005). In addition, the experimental group has to answer a set of questionnaires to gauge their perceptions towards the usage of Geometer's Sketchpad software. Figure 2 shows the flow chart of the research process.

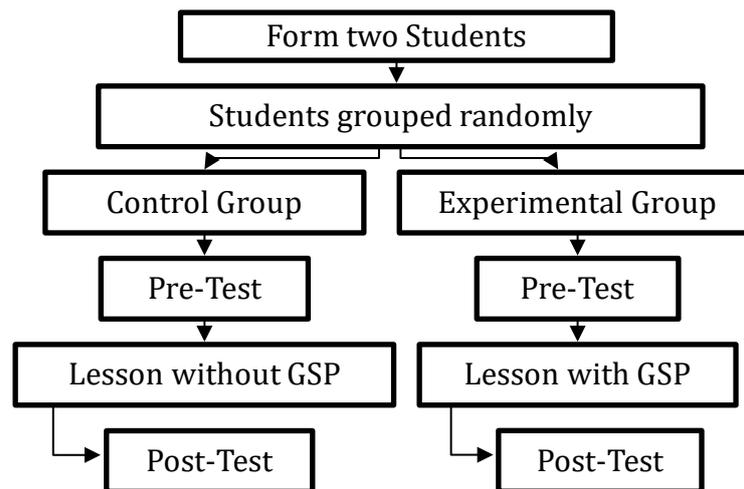


Figure 1. flow chart of

the collection of data

Data Analysis

The collected data consists of data from pre and post-test performance of students. SPSS software has been used to analyze this data. Analyzing data involves Descriptive Statistics and Statistical Inference. Descriptive statistics were used to show the marks mean, variance, standard deviation and minimum and maximum marks. Next, Statistical Inference used to test hypotheses about the differences in student achievement in accordance with the methods used to analyze the distribution of the *t*-test. Geometer's Sketchpad effectiveness was tested by comparing the difference in the mean values for the pre test and post-test for both groups (control and experimental). Next, the differences between the mean values of these tests were analyzed using paired *t*-test analysis. This method is suitable for finding the difference of two mean values for the same group. The effectiveness of GSP in improving student achievement was supported where there is a significant improvement from pre-test to post-test of the experimental group but not in the control groups.

Validity and Credibility

The instrument used to assess effectiveness of GSP based instruction in enhancing students' statistical reasoning had undergoes pilot study before it can be administered. A pilot study was intended to examine any weakness in the research design. The pilot study was conducted under the same condition using similar ability respondents and the same instrument planned for the real study. There were 30 students participated, the pre-post test instrument obtained Cronbach Alpha of .74 hence the coefficient indicated that the instrument was reliable. Questionnaire items required responses on a five-point Likert scale with scores ranging from "strongly disagree" to "strongly agree". A reliability test was conducted on the Students' Perception Questionnaire obtained a Cronbach alpha of 0.91, indicating internal consistency of the scale. In addition, two experienced teachers validated the test and questionnaire on the concepts, skills, difficulty level and clarity of the questions as well as the language. Their comments and recommendations were used to improve the questionnaire.

FINDINGS

The analysis and findings mentioned in the research methodology is presented in this chapter.

H_{o1}: What is the effectiveness of using GSP on students' understanding of circle as compared to the traditional approach?

To answer the first research question, an independent samples t-test was conducted to determine whether the mean score of the pre-test differed between the control and experimental group. Review of the Shapiro-Wilk test of normality ($S-W = .98$, $df = 82$, $p = .51$) indicated that normality assumption was not violated.

Table 1. Results of the independent t-test on the pre-test and post-test of both groups

	Group	Mean	SD	t-value	Sig (2 tailed)
Pre-Test	Experimental (n=40)	59.98	15.03	-1.043	.30
	Control (n=42)	56.64	13.91		
Post-Test	Experimental (n=40)	71.60	13.47	-4.197	.000
	Control (n=42)	59.10	13.50		

t-value significant at $p < .05$

Table 1 shows that the experimental group obtained pre-test mean score of 59.98 ($M=59.98$, $SD=15.03$) meanwhile the control group obtained a mean score of 56.64 ($M=56.64$, $SD=13.91$). The mean score difference between the groups was 3.34 with a $t(80) = -1.043$, $p > .05$. Therefore, we fail to reject the null hypothesis indicating that the difference in the mean score of the two groups was not significant. This result showed that both the students in the control and experiment group were similar in abilities before the treatment was administered.

Meanwhile the control group's mean score between pretest ($M=56.64$) and posttest ($M=59.10$) showed that the students had scored better after taught in traditional group. This is because the pretest was done before the lesson begins whereby the students are with lack of knowledge in the particular topic. After conduct the lessons, the students gained understanding on the statistical reasoning, this is the main reason why their score is improved. However, this study intend to examine effectiveness of two different teaching method. Hence there is a need to compare between traditional method and GSP method.

In the post-test the experimental group has a mean score ($M=71.60$, $SD=13.47$) while the control group has a mean ($M=59.10$, $SD=13.50$). The mean score difference between the groups was 12.5. The computed t-value between the post-tests of the experimental and control groups is $t(80) = -4.197$, $p < 0.05$. This indicates that there is a significant difference between the post test of both groups. Based on Cohen's (1988) criteria, the effect size of 0.89 is large. These results indicate that learning Circle using GSP do differs in students' achievement. This finding illustrated that the experimental group students performed better using Geometer's Sketchpad than the control group using the traditional learning method.

Table 2. Results of paired sample t-test

	Mean	S.D	t	Sig. (2 tailed)
Pair 1 Post-test score – Pre-test score (Experimental)	6.93	9.99	6.28	.000

t-value significant at $p < .05$

A paired sample t-test was conducted to compare the pre-test and post-test for experimental group with the mean and standard deviation score score ($M=6.93$, $SD=9.99$). The results as illustrated in Table 2

shows that the mean score difference between the post-test and pre-test was 6.93 with a *t*-value obtained was, $t(40)=6.28, p<0.05$. The null hypothesis was rejected indicating that the differences between the pre and post test score was significant. This result showed that learning using GSP improves students' achievement in Circle.

H₀2: What are the students' perceptions about using the Geometers' Sketchpad in the learning of Circle?

Table 3. Students' perception on the usage of GSP

Items	Mean	Standard Deviation
1. The Geometer's Sketchpad is easy to use.	3.45	0.75
2. The Geometer's Sketchpad can illustrate diagram more clearly.	4.20	0.76
3. The Geometer's Sketchpad helps me in my discussions in the classroom.	4.25	0.54
4. Learning mathematics is more fun now.	4.15	0.66
5. I get to learn the topic on Circle in greater depth.	3.85	0.74
6. I can draw and solve problem with the Geometer's Sketchpad.	3.45	1.08
7. Learning mathematics is easier now.	3.25	0.98
8. I understand my lesson better when using the Geometer's Sketchpad compared to using textbooks.	3.88	0.91
9. I get to interact with both my teacher and friends in the classroom when I use the Geometer's Sketchpad.	4.25	0.81
10. I am more confident at solving problems in the Circle.	3.20	0.72
11. The Geometer's Sketchpad guides me to solve the difficult sums.	3.38	0.84
12. Now, I enjoy mathematics.	4.13	0.69
13. Using the Geometer's Sketchpad is a good way for me to learn Circle.	3.63	0.83
14. I acquired a good experience from the opportunity to use Geometer's Sketchpad.	3.83	0.81

Note: Assessment scale had minimum and maximum values of 1 (strongly disagree) and 5 (strongly agree).

Table 3 showed the respond of the students' perception on the use of GSP in teaching and learning in Circle. It showed that the GSP able to illustrate diagrams clearly (M = 4.20) and the students acquired a good experiences with the use of GSP (M = 3.83). On the other hand, most of students also agreed that they had enjoyed the lesson with the use of GSP (M = 4.15), which make them confident in solving problem involving Circle (M = 3.20). Another important aspect is the communication with both teacher and friends (M = 4.25). Thus, most students agreed this helped the discussions in classroom (M= 4.25).

For more detail, students' responses were again computed and divided into four categories. The selected categories of the responses considered as:

- i. students' perceptions on the usage of Geometer's Sketchpad, (Item 1, 11 and 14)
- ii. students' perceptions on how Geometer's Sketchpad helps understanding, (Item 2, 5, 6, 8, 10 and 13)
- iii. students' perception on their abilities to communicate when using Geometer's Sketchpad. (Item 3 and 9)
- iv. students' perception on their attitudes towards geometry, when using Geometer's Sketchpad. (Item 4, 7 and 12)

The results were tabulated according to the categories and summarized in frequencies and percentages. Table 4 showed the students' perception on the usage of GSP.

Table 4. Students' perceptions on the usage of Geometer's Sketchpad

Items	1 Strongly Disagree	2 Disagree	3 Neutral	4 Agree	5 Strongly Agree
1. The Geometer's Sketchpad is easy to use.	0 (0)	9 (22.5)	5 (12.5)	15 (37.5)	11 (27.5)
11. The Geometer's Sketchpad guides me to solve the difficult sums.	0 (0)	5 (12.5)	19 (47.5)	12 (30.0)	4 (10.0)
14. I acquired a good experience from the opportunity to use Geometer's Sketchpad.	0 (0)	3 (7.5)	8 (20.0)	22 (55.0)	7 (17.5)

Based on the Table 4, the first category that is usage of GSP, the results showed that 65% of students agreed that GSP is easy to use. A small percentage (12.5%) was not sure; meanwhile remaining 22.5% of students did not agree that it was easy. As whether GSP guided students to solve the difficult sums, only 40% agreed and most of students (47.5%) were not sure. Five out of forty disagreed. The high percentage of not sure for item number 1 and 11 might be due to the seldom use of the computer in classroom. However, the majority of students agreed (72.5%) that they acquired a good experience with the use of GSP, while only three out of forty disagreed. Remaining 20% of students were uncertain.

The next category inquired on whether using GSP could help the students in their understanding of mathematics specifically in topic circle. As in the following Table 5, almost all the students (90%) agreed that the GSP able to illustrate diagrams clearly.

Table 5. Students' perceptions on how Geometer's Sketchpad helps understanding

Items	1 Strongly Disagree	2 Disagree	3 Neutral	4 Agree	5 Strongly Agree
2. The Geometer's Sketchpad can illustrate diagram more clearly.	0 (0)	2 (5.0)	2 (5.0)	22 (55.0)	14 (35.0)
5. I get to learn the topic on Circle in greater depth.	0 (0)	0 (0)	14 (35.0)	18 (45.0)	8 (20.0)
6. I can draw and solve problem with the Geometer's Sketchpad.	2 (5.0)	6 (15.0)	10 (25.0)	16 (40.0)	6 (15.0)
8. I understand my lesson better when using the Geometer's Sketchpad compared to using textbooks.	0 (0)	5 (12.5)	4 (10.0)	22 (55.0)	9 (22.5)
10. I am more confident at solving problems in the Circle.	0 (0)	7 (17.5)	18 (45.0)	15 (37.5)	0 (0)
13. Using the Geometer's Sketchpad is a good way for me to learn Circle.	0 (0)	5 (12.5)	10 (25.0)	16 (40)	8 (20.0)

Only 5% was neutral or uncertain. Two out of forty disagreed. For the next item, number 5, 65% of students agreed that they learn the topic circle in greater depth. The remaining students 35% were uncertain while no students disagreed. The percentage 55% of students agreed that they able to draw and solve problem with GSP whereas 30% of students disagreed. 10 out of forty students were uncertain. Most of students agreed (77.5%) that they understand the lesson well when using GSP compared to textbooks. Only 5 students (12.5%) disagreed and the balance of 4 students (10%) were unsure. The next item number 10 showed majority of students were neutral (45%) on being confident at solving problem in the topic circle and only 37.5% agreed that they are confident in problem solving. Meanwhile rest of students (12.5%) disagreed. Since students are not highly exposed to learning with technologies hence they still had uncertainty in utilizing technology in learning mathematics. Lastly, item number 13 which stated that using GSP is a good way for students to learn circle and majority of students had agreed (60%). There are only 5 students (12.5%)

disagreed and 25% of the students were uncertain.

Table 6. Students' perception on their abilities to communicate when using Geometer's Sketchpad

Items	1 Strongly Disagree	2 Disagree	3 Neutral	4 Agree	5 Strongly Agree
3. The Geometer's Sketchpad helps me in my discussions in the classroom.	0 (0)	0 (0)	2 (5.0)	26 (65.0)	12 (30.0)
9. I get to interact with both my teacher and friends in the classroom when I use the Geometer's Sketchpad.	1 (2.5)	0 (0)	6 (15.0)	15 (37.5)	18 (45.0)

The third category is on the abilities to communicate when using GSP. Table 6 showed that majority of the students agreed (95%) that GSP had helped them in their classroom discussion and only 5% were uncertain. Under classroom interaction with both teachers and peers, again the majority of students agreed (82.5%) that GSP encourages them to interact. Only a small percentage disagreed (2.5%) and the remaining 15% were not sure.

Table 7. Students' perception on their attitudes towards geometry when using Geometer's Sketchpad

Items	1 Strongly Disagree	2 Disagree	3 Neutral	4 Agree	5 Strongly Agree
4. Learning mathematics is more fun now.	0 (0)	0 (0)	6 (15.0)	22 (55.0)	12 (30.0)
7. Learning mathematics is easier now.	1 (2.5)	1 (2.5)	12 (30.0)	16 (40)	10 (25)
12. Now, I enjoy mathematics.	0 (0)	1 (2.5)	4 (10.0)	24 (60.0)	11 (27.5)

Table 7 showed the students' attitudes towards mathematics. A total of 85% of the students agreed that learning mathematics is more fun with GSP while 15% were uncertain. In fact none of the students disagreed. About 65% of the students agreed that learning mathematics is easier with GSP while 30% of students were uncertain. Only 2 out of forty (5%) disagreed. The high percentage of not sure responses might be due to student unfamiliarity with GSP. However, majority of students agreed (87.5%) that they enjoy learning mathematics with GSP. Least percentage of students had disagreed (2.5%) and only four students were not sure.

In summary, the results concluded that most of the students who use GSP enjoyed mathematics and found the lesson more interesting. The GSP had the ability to construct and solve problem involving circle and other geometer topics. Plenty of students also testified that they are able to communicate with teacher and friends and help in classroom discussions.

DISCUSSION AND CONCLUSION

In this study, Geometer's Sketchpad was used as a tool in teaching and learning Circle. The results showed that the mean score of post-test result for the treatment group and the control group have a significant differences. Therefore, the use of computer-aided teaching aids which is GSP had make an impact on teaching and learning Circle topic. Students performed better after the using the GSP. The results of this study are consistent with several studies that discovered the use of interactive multimedia is necessary to

encourage and improve students' understanding in mathematics that can enable student to achievement better in Mathematics (Bakar, Ayub, Luan, & Tarmizi, 2010; Dimakos & Zaranis, 2010; Marzita & Rohaidah, 2004; Tezer & Kanbul, 2009; Young, Gorumek, & Hamilton, 2018). Students can obtain better understanding from well-structured instructional activities together with teacher's guidance and suitable facilities (McKnight et al., 2016; Meng & Sam, 2013).

The result obtained from students' perception questionnaire from the experimental group shows positive feedback from the students, which implied that the learning circle with Geometer's Sketchpad had been beneficial and useful for the students. Students feel it is exciting when the learning style is different from the conventional method. Besides that, technology in education especially in mathematics helps to create a less stressful environment for both teachers and students. Especially when the students are able to communicate and involve in classroom discussions with teachers and friends, the classroom environment in will be more enjoyable and fun (Oldknow & Taylor, 2002). Indirectly, students will be more capable in solving mathematical problems (Zakaria, Daud, & Nordin, 2007).

IMPLICATIONS AND LIMITATIONS

The findings of this study have raised implications for teachers and students as well. Teachers could save their time preparing teaching tools by using ICT as the teaching tool. Use of mathematical software could create more meaningful classroom teaching. GSP is a great platform for the students to learn independently by exploring, analyzing and collaborating. However, the students should be given more time to experience learning with GSP.

It is recommended that more study on the application of GSP should be carried out in future to promote better learning style among students and enhance higher order thinking skills. Moreover, teachers are catalysts in assisting students in effective use of technology while learning mathematics. Therefore, study on other dynamic and interactive learning environments for mathematics, such as Cabri, GeoGebra, Geometer Sketchpad and Fathom can be of great help for the teachers in improving student knowledge and understanding of mathematics, especially in dynamic and complicated subject matters. By means of the materials prepared by using these types of software, students can configure mathematical concepts with their own generalizations with the teacher's guidance. For this reason, it is very important to conduct research so that can provide training to the implementers or teachers on how to carry out lesson using technology and what kind of materials they can create by software for use in such instruction.

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