The effects of using GeoGebra teaching strategy in Malaysian secondary schools: A case study from Sibu, Sarawak

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Abstract

As computer-based technology becomes an important component of any modern curriculum, the continuing challenge is to scrutinize the applications of the instructional technology and to identify whether these tools can give good benefit to students' learning process. This study examined the effects of using GeoGebra Teaching Strategy in learning Circle III topic on Malaysian Secondary Form Four students' performance and attitudes towards this teaching strategy. A quasi experiment of non-equivalent pre-posttest control group design study was conducted in a school in Sibu, Sarawak. One control group (n = 17) and one experimental group (n = 29) were randomly selected from Form Four classes. The experimental group underwent learning using GeoGebra Teaching Strategy meanwhile the control group underwent learning using Conventional Teaching Strategy. The Circle III Achievement Test and the Attitude Questionnaire were used as instruments in this study. The data were analyzed using one way ANCOVA and one sample t-test. The analysis showed that there was no significant difference between mean performance scores of students in experimental and control groups. However, the experimental students showed positive attitudes towards using GeoGebra software while learning Circle III topic. This indicated that not only could this strategy be utilized in learning mathematics but also in enhancing Malaysian students' performance in learning mathematics in the long run.

Keywords: conventional teaching strategy, GeoGebra teaching strategy, human capital, Quasi-experiment non-equivalent pre-posttest control group design, Circle III topic, Malaysian Secondary Mathematics

Introduction

In today's world, computer-based technology can be considered as one of an important component of any modern curriculum (Ringstaff & Kelley, 2002). The continuing challenge is to scrutinize the applications of the instructional technology and to identify whether these tools can give good benefit to students' learning process. In math education, computers have raised the importance of certain ideas, made some problems and topics more accessible, and provided new ways to represent and handle mathematical information, affording choices about content and pedagogy that we've never had before. Many mathematics software have been introduced and widely practiced all over the world, such as Geometer's Sketchpad (GSP), Autograph, Maple, Matlab, Mathematica and so on (Kamariah, Ahmad Fauzi & Rohani, 2010a). These tools have been proven to be a very important aspect in the teaching and learning process. For example, Rohani et al. (2010) has showed the importance of Autograph, an educational software which can be used by students to change and animate graphs, shapes or vectors already plotted. This activity can stimulate students' interest, encourage understanding of concept and further understand mathematical phenomenon in real life.

In Malaysia, the use of technology in mathematics teaching and learning has consistently been a major focus in Malaysian Integrated Curriculum for Secondary School (Ministry of Education Malaysia, 2004). Teachers are encouraged to use the latest technology to help students in understanding mathematical concepts in depth and able to explore the mathematical ideas as an abstract concepts which are important things in understanding and performing mathematics. Harizon (2005) has reported that students having difficulties in determining the properties of two tangents, verifying the relationship between the angle formed by the tangent and the chord with the angle in the alternate segment, and solving questions related to the common tangent to two circles in Circle III topic. They couldn't grab the concept accurately as they hardly imagine the concepts and its application. Therefore teaching materials in the form of images are used in order to help students to information better as well as to build link between new information and experience and their existing knowledge base. Besides that, Chianson et al. (2010) found that students have problem in grasping and memorizing mathematical concepts in circle geometry as well. Since the topic of Circle III demands the students to imagine on the relationship between angles and tangents, therefore this topic is selected in this study.

GeoGebra has many constructive features and is useful in visualizing mathematical concepts (Green & Robinson, 2009; Harizon, 2005; Kamariah et al., 2010b; Lu, 2008). Utilizing GeoGebra as a teaching tool is not a new thing for foreign countries (Hohenwarter et al., 2008; Lu, 2008). GeoGebra is a free, open-source and dynamic mathematics software and is rapidly gaining popularity in the teaching and learning of mathematics around the world. Currently, GeoGebra is translated to 62 languages, used in 190 countries, and downloaded by approximately 500,000 users in each month, and clearly making an impact on mathematics education in most countries (Lavicza, 2012). However, the use of open source software in teaching and learning mathematics is still can be considered new in Malaysia (Kamariah et al., 2010a).

Literature reviews

A. GeoGebra software

GeoGebra software is the combination between Computer Algebra System (CAS) which provided visualization capabilities and Dynamic Geometry System (DGS) which provided dynamic changeability (Lu, 2008). The visualization of Algebra Window and Geometry Window provides a connection between algebraic and geometric representations. In Geometry Window, points can be moved along function graphs, parameters are changeable using sliders, and text adapts automatically to changes (Hohenwarter et al., 2008). It is also a convenient and easy way to generate graphics and visuals for presentations, test questions, and homework questions and learning to use this application is straightforward (Garber & Picking, 2010). GeoGebra should be able to ease teachers' burden if the teachers are ready and committed to learn on educational software teaching. The application of this software can help to build a fun learning environment where students can explore the mathematical concept differently compared to conventional teaching. GeoGebra able to build chart, graph, tangent and angles easily and very convenient as the instructions are provided and shown in the menu bar. The color of the background and different colour on certain words in GeoGebra window can help in emphasizing mathematical concepts. Besides, it can help the students to focus on lesson. Many advantages of GeoGebra are found especially in mathematics visualization (Joubert, 2009; Lu, 2008; Hohenwarter et al., 2008; Kamariah et al., 2010a, 2010b). This software is much easier to deal compared to Mathematica and Maple which requests programming and coding skills. Moreover, the application in GeoGebra is straightforward and only little instructional and set up time are needed (Garber & Picking, 2012). By using the GeoGebra, teacher can experience some changes in teaching and learning mathematics. Hence, in this study, GeoGebra Teaching Strategy (GTS) is introduced in order to help students to have better understanding on mathematical concepts in learning Circle III topic.

B. Researches on technology in Mathematics teaching and learning

In this world of globalization, many mathematics software have been introduced and implemented as a computer-support learning to help students to be actively thinking about information, making choices, and executing skills compared to conventional teaching (Rohani et al., 2010). The use of technology can help to enhance understanding of abstract mathematical concepts by enhancing students' visualization or graphic representation on relationships between objects and their properties. This is supported by Yushau and Wessels (2005) who have reported that one of the unique features of the computer as a teaching and learning tool is in visualizing the concept of the mathematical problem so that it can be solved easily.

Many studies showed that there is an improvement on students' achievement when GeoGebra is implemented in mathematics teaching and learning process (Royati et al., 2010; Kamariah et al., 2010b). For example, Zengin, Furkan and Kutluka (2012) have reported that a general high school in Diyarbakir has showed a significant difference between mean performance scores of the control group compared to GeoGebra group when the GeoGebra software was integrated in the teaching and learning process for five weeks. Royati et al. (2010) showed that GeoGebra instruction is more effective than the traditional instruction alone in teaching Geometry Coordinate topic. The finding of the study showed that the low visual-spatial students in the GeoGebra group significantly outperformed the low visual-spatial students in the control group. Another study by Kamariah Abu Bakar et al. (2010a) also showed that the GeoGebra and another open source software, E-tranformation have helped to improve students' mathematics achievement. Students' motivation in understanding mathematical concepts are enhanced too with technology implemented (Kamariah Abu Bakar et al., 2010).

Rohani et al. (2010) have investigated the cognitive factors enhanced with the integration of interactive software Autograph in comparison to the conventional way for teaching Calculus at the secondary level. Their findings showed that integrated learning strategy is instructionally more efficient compared to the conventional instruction strategy. This was because Autograph users able to change and animate graphs, shapes, or vectors in understanding a concept. This study shows promising implications for the potential use of Autograph software as a tool in teaching mathematics at Malaysian secondary school level. Besides that, Harizon (2005) found that the perception of the teachers and students towards using computer and Geometry software in teaching and learning mathematics was highly positive. A study conducted by Kor and Lim (2009) found that the students enjoyed GSP class and they felt that the GSP lesson was interesting. Student can concentrate to the teaching and learning process because they can visualize mathematical concepts clearly, can get engaged in mathematics learning by GSP due to its visual abilities and animation. The integration of GSP in teaching and learning of mathematics also has gained positive responses from teachers (Kasten & Sinclair, 2009). Furthermore, graphic calculator is also popularly used in teaching and learning mathematics nowadays. It helps students to think the procedural knowledge such as what information to enter, what operation to use and finally ways to interpret the result in order to solve mathematics problems besides using it (Nor'ain et al., 2011). Hence, it developed students' understanding of mathematical concepts without losing their procedural knowledge. The graphic calculator also can help students in better understanding of linear equations (Simons, 2009). Basically, it is hard to see the changes of slope and y-intercept on a graph paper when the coefficient is changed. However, students could graph linear systems by using graphic calculator and can see the changes. In short, the finding showed the graphing calculators increased student understanding of linear equations. From these studies, it was found that students able to understand the concepts better when they are actively engaged and motivated via technology.

However some studies showed that the control group performed better compared to the experiment group. For example, Nurihan (2005) showed that there was no significant mean difference in post test scores between students in experimental group and control group. And surprisingly, the mean scores of control group is even clearly better than experimental group. This was because two periods of treatment lesson was insufficient enough to make an influence on students' performance. This result is in the line with a study conducted by Rohani et al. (2009) on integrating the Autograph technology for learning Form Four Algebra. They found that some factors such as the time constraint, lack of focus on the students' part during teaching and learning activity, the teachers' factor and improved learning module for the students are suspected may lead to the result that the conventional strategy group performed better than the conventional group.

In summary, the literature reviews show some evidences that generally the results have favored the use of technology in mathematics education. This study is pertinent to encourage awareness among mathematics educators of the potential of using GeoGebra software technology and to share ideas and ways how to plan a well-designed lesson, designing instructional activities systematically, selecting strategies appropriately and creating mathematical tasks that take the advantage of this technology. Therefore, the main objectives of this study is to investigate the effect of GeoGebra Teaching Strategy (GTS) in teaching Circle III topic among Form Four students and also to determine students' attitude towards GTS in learning Circle III topic. The conceptual framework for this study is given in Figure 1. The types of teaching methods, CTS and GTS are considered as independent variables. Students' test performance and their attitude towards GTS in learning Circle III topic are considered as the dependent variables.

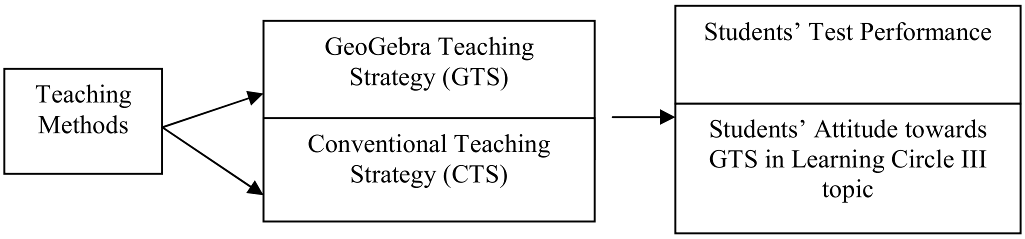

Figure 1. *Conceptual framework of the study*

Therefore, the research hypotheses of this study are:

1. There is a significant different on mean scores of Form Four students' test performance between Conventional Teaching Strategy (CTS) and GeoGebra Teaching Strategy (GTS) in learning Circle III topic.
2. There is a significant difference between sample mean and hypothesized mean on Form Four students' attitude towards GTS in learning Circle III topic.

Research methodology

A. Design of the study

A quasi-experimental nonequivalent pre-posttest control group design is implemented in this study to test the use of GTS in learning Circle III topic (Table 1). This design is most appropriate in investigating effectiveness of an intervention with the availability of intact groups and is used whenever the true experimental design is not feasible (Creswell, 2008; Fraenkel & Wallen, 2006).

Table 1. Quasi experimental nonequivalent pre-posttest control group design

Group		Independent Variable	
E	Y_1	X	Y_2
C	Y_1	-	Y_2

E – Experimental Group Y_1 – Pretest   X – GeoGebra Teaching Strategy (GTS)
C – Control Group Y_2 – Posttest   - – Conventional Teaching Strategy (CTS)

From Table 1, “X” indicates an experiment treatment, and “dash” indicates no experiment treatment. The “Y”s indicate the measurement made during the pretest and posttest. The survey method is employed to the students’ attitudes towards GTS.

B. Population and sample of the study

The target population of this study was Form Four students in national secondary schools in Sibu, Sarawak. The samples selected for this study were Form Four students from a randomly selected school after which permission was approved by the Ministry of Education and the school management to conduct the study. There are seven Form Four classes in the school. Two best and weakest classes were omitted as these groups of students may not have the same characteristics as those from the average classes. By using a fish-bowl method, two classes were assigned as experimental and control groups. The experimental group undergone the GTS and the control group was the Conventional Learning group. The total number of students in experimental group was 29 and control group was 17. According to Gall, Gall and Borg (2010), there should be at least 15 participants in each group to be compared in experimental research. Thus, the sample sizes for both groups are appropriate in conducting the study.

C. Instrumentation

There were two instruments used in this study, namely the Circle III Achievement Test (C3AT) and Students’ Attitude towards GTS Questionnaires (SAGQ). The C3AT was used to assess students’ pretest (C3AT 1) and posttest (C3AT 2) performance in Circle III topic. It comprised of four main subjective questions: four items in the first question, two items in the second question, three items in the third question, and two items in the fourth question. These questions were based on a test specification table and selected and modified from the Form Four Mathematics textbook (Lim, Khoo & Samadi, 2004) and mathematics reference book (Mun, 2005). The SAGQ was used to measure students’ attitude towards GTS in learning Circle III topic. In this study, a set of questionnaire with 22 items was adapted and modified based on several attitude questionnaires on mathematics technology (Barkatsas, 2005; Barkatsas, 2009; Galbraith & Haines, 1998; Mohd Lazim , Wan Salihin & Abu Osman, 2005; Pierce, Stacey & Barkatsas, 2007; *Pierce & Ball, 2009).* Likert scale was used in this questionnaire, with options ranged from 1 (Strongly disagree) to 5 (Strongly Agree). Both instruments were validated by education experts and established reliable alpha Cronbach indices, where the reliability of pretest was 0.649, the reliability of posttest was 0.645 and the reliability of the SAGQ was 0.84.

D. Procedure

Both groups are given the C3AT 1 at the same time. None of the groups have learned about Circle III by GeoGebra before. The Circle III topic is conducted and handled under the same teacher. The GeoGebra integrated in teaching was introduced only to the experimental group meanwhile the control group underwent the conventional teaching. This helped to achieve compensatory equalization and thus reduce threats to the internal validity.

In this study, the CTS group learned through direct instruction and lectures from the teacher, seatwork, listening and observation. The examples and drawings from the textbooks were used during the teaching sessions. There was no outdoor activity and students need to complete their exercises on their seats. For GTS, the examples and drawings on the textbooks were constructed with the GeoGebra software and shown during the teaching sessions by referring to the GeoGebra Worksheet (GW). In this GW, users were given instructions to learn the mathematical concepts of Circle III topic by exploring and investigating mathematical ideas, conjectures with the GeoGebra software. The changeability and visualization of images enable the users to master the concepts in Circle III topic better. Appendix A and B showed one example of the details of the activities given to control and experimental groups respectively.

The C3AT 2 with same format but different questions as C3AT 1 was given to both groups after two weeks of teaching Circle III topic. At the end of the experiment, the SAGQ was distributed to the experimental group. The questionnaire was given before the posttest to avoid any possible influence arising from the response to the posttest which may lead false responses on the attitude test (Schenkel, 2009).

Results and discussion

A. Effect of CTS and GTS on students' performances

Table 2 shows the analysis of means and standard deviations of the variables meanwhile the main result of ANCOVA is given in Table 3.

Table 2. Mean scores of pretest and posttest of CTS and GTS

Teaching Method	Mean		Std. Deviation		N
	Pretest	Posttest	Pretest	Posttest	
CTS	5.51	26.10	5.797	19.576	17
GTS	21.12	53.77	11.977	25.990	29
Total					46

The overall performance test ranged between 26.10 and 53.77. The results in Table 2 showed that mean scores of pretest for control group was 5.51 and mean scores for experimental group was 21.12. Mean scores of posttest for control group was 26.10 and mean scores for experimental group was 53.77.

The result of ANCOVA showed that there was a significant relationship exists between Pretest (covariate) and the dependent factor (Posttest), [F (1, 43) = 4.780, $p < .05$]. However, there was no main effect of fixed factor (Teaching Method) and dependent variable (Posttest), [F (1, 43) = 3.354, $p > .05$]. Therefore, when Pretest is statistically controlled, teaching method has no influence on Posttest.

Table 3. ANCOVA result

Dependent variable: Posttest

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	10710.483[a]	2	5355.242	10.216	.000	.322
Intercept	14524.659	1	14524.659	27.710	.000	.392
Pretest	2505.763	1	2505.763	4.780	.034	.100
Teaching Method	1757.852	1	1757.852	3.354	.074	.072
Error	22539.559	43	524.176			
Total	120478.516	46				
Corrected Total	33250.042	45				

a: R Squared = .322 (Adjusted R Squared = .291)

The effect size as indicated by the corresponding Partial Eta Squared value was .072 which is a medium effect size according to Cohen's conventions for effect size, R^2 (Ary et al., 2010) where the guideline for interpreting $\eta^2 = .06$ is a medium effect. This value also indicated how much of the variance in the dependent variable was explained by the independent variable. In this study, 10.0% of the variance in the posttest was explained by the variable of Pretest. Besides that, it was showed that only 7.2% of the variance of the posttest was explained by the variable of teaching method.

Table 4. Estimated marginal means

Dependent variable: Posttest

Teaching Method	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
CTS	33.413[a]	6.482	20.342	46.485
GTS	49.486[a]	4.682	40.045	58.927

a: Covariates appearing in the model are evaluated at the following values: Pretest = 15.35.

The final table in the ANCOVA output (Estimated Marginal Means) has provided the adjusted means on the dependent variable for each of the groups. “Adjusted” refers to the fact that the effect of the covariate has been statistically removed (Pallant, 2010). Table 4 showed that the adjusted mean of posttest for control group was 33.41 while the mean of posttest for experimental group was 49.49.

A one-way between groups analysis of covariance (ANCOVA) was conducted to compare the effect of teaching method among the control and experimental group. It was found that the teaching method has no influence significantly on the Posttest when the Pretest was statistically controlled, as shown in Table 3, [F (1, 43) = 3.354, $p > .05$]. Therefore, the first hypothesis was not accepted which showed that there was no significant different on mean scores of students’ test performance between the CTS group and the GTS group in learning Circle III topic. However, Table 4 showed that the GTS group still showed better test scores($\underline{M}$ = 49.49) compared to the CTS group ($\underline{M}$ = 33.41).

In this study, it was showed that there was no significant difference on mean scores between GTS and CTS. This was comprehensible with the findings of the study done by Ong and Ahmad Nizam (2009) who reported that there was no statistically significant difference in biology’s achievement between students with cartoon module and students with conventional learning. It was because the intervention period for experimental group was only 80 minutes and these hardly to show the effectiveness of cartoon module.

This result is consistent with Harizon (2005) who has conducted a study with GSP integrated in teaching and learning tangent to a circle subtopic. The finding of the study showed that there was no significant difference between the posttest scores of experimental group and the control group. Based on this finding, she suggested that they need at least more than a month for the teaching and learning process in order to evaluate the effectiveness on teaching method towards students’ performance. However, the finding also showed that the mean scores for experimental group was higher than control group, indirectly showed that GSP at least contribute better students’ performance than the conventional teaching.

Marzita and Rohaidah (2002) also have suggested that longer time was required in order to detect the effectiveness of using GSP. They explained that it is hard to evaluate the effectiveness of software integrating in teaching and learning for certain mathematics topics in a few weeks only. If the study carried out in a longer duration, one or two years, the achievement would be better shown. For example, Zengin et al. (2012) have carried out a five weeks course with GeoGebra software integrated at a general high school in Diyarbakir and showed that there was a significant difference between mean performance scores of the control group and the experimental group.

Therefore in this study, the time duration factor was suspected has became the major issue that caused the result, where there was no significantly difference in the mean scores between both groups. The two weeks duration of integrating the GTS in teaching and learning Circle III topic was insufficient to check the effectiveness of the GTS. Hence, it was suggested that to have longer treatment duration is needed in this study in order to evaluate the effectiveness of GeoGebra software in learning Circle III topic.

Another factor that contributed to the result was not much opportunity was given to students in this study to manipulate the GeoGebra software while learning Circle III topic. Most of them only can listen and watched the demonstration which was done by the teacher. Gao (2006) mentioned that a technology hardly can make a difference in teaching and learning if it is used in a traditional way as a replacement for teachers and textbooks to impart on basic knowledge and skill. Therefore, student-centered with technology integrated is encouraged and preferred in order to achieve and maximize the use of technology. In this study, we believe that the result of mean scores between both groups would be significantly different if all students in the experimental group were provided with a computer with GeoGebra software installed and hence, they will be able to explore and investigate the mathematical concepts they have learnt by themselves. Furthermore, students would learn, explore, and understand better when they able to manipulate the GeoGebra software in answering questions in GoeGebra Worksheet (GW). This condition was similar with a study done by Harizon (2005). In that study, only the teacher used GSP in teaching tangents to a circle subtopic and therefore, involvement of students using the software itself was quite minimal. The students couldn't explore the GSP by themselves in order to further understand the mathematical concepts and hence cause no significant different between GSP teaching and conventional teaching. As a conclusion, students should be encouraged to use the technology during the learning process so that they can explore the mathematical concepts themselves. This can help to stimulate and prolong their memories on the concepts, hence produce a better performance scores.

From Table 2, it was shown that the mean posttest scores of students in the control group was 26.10, meanwhile the mean posttest scores of students in the experimental group was 53.77 which were not excellent but passable. Reis and Gulsecen (2010) have reported that there are a few factors influenced the results of the exam such as students revising or not revising, doing or not doing exercises, and unaware that they are having a test. These might also the cause factors that the GTS became ineffective to the experiment group. However, Table 4 showed that GTS still able to help students from the experiment group to improve better in their performance. Therefore, it was suggested to teach Circle III topic with GW so that it is in the line with the National Council of Teachers of Mathematics (2000; 2008) that the use of technology should be maximized in order to develop students' understanding, stimulate their interest, and increase their proficiency in mathematics.

There are several researches reported that module with software integrated could help the teaching and learning process. Wan Ranizira (2007) has developed a courseware with module, *Modul Multimedia Fizik (MMH)* on Heat topic by using the Swish MX and Microsoft Visual Basic software. The findings showed that there was a significant different between students using *MMH* in teaching and students with conventional teaching. This result was consistent with Che Adan (2008), who has applied an electrochemical module based on Microsoft Office PowerPoint and Micro Media Flash MX in teaching the electrolysis and chemical cell topics. The finding showed that these software were significantly can help students in reducing students' misconceptions in these topics. In addition, Hasnira (2005) has reported that the students' performance who have undergone with courseware *Multimedia Elektrokimia (PME)* and its module in their learning have increased significantly as the animation, graphics, and color text of this courseware can help to attract students' attention and made the lesson more interesting. Moreover, *PME* has provided the opportunities to students to revise and learn based on their learning pace as they were able to start the reading and revision on module anytime and anywhere.

This situation is the same as using GW where student can do their study and revision on Circle III topic without the limitation of time and location by using the module together with the GeoGebra software. Moreover, students are more involved in their learning process with GeoGebra software incorporated with their learning activities. As a conclusion, the integration of mathematical software in the teaching and learning process not only can help students to have better understanding in mathematical concepts but also to prepare them in this high-tech world as well (Kamariah, Ahmad Fauzi & Rohani 2010b).

B. Students' attitude towards GTS

One sample *t*-test is conducted to determine students' attitude towards GTS in learning Circle III topic. Table 5 provides the mean and standard deviation and analysis of one sample *t*-test on students' attitude score.

Table 5. One-sample *t*-test on students' attitude

	Test value = 66						
	T	df	Sig. (2-tailed)	Mean Difference	N	Mean	Std. Deviation
Students' Attitude	13.318	28	.000	20.069	29	86.07	8.115

Table 5 showed that the mean scores of students' attitude from the experimental group was 86.07 and standard deviation was 8.12. Hence, the mean of students' attitude, 86.07 was greater than the hypothesized mean, 66. This indicated that students have positive attitude towards GTS in learning Circle III topic. There was a significant difference between sample mean and hypothesized mean on students' attitude towards GTS in learning Circle III topic, t (28) = 13.32, $p < .05$. This indicated that students would not avoid but enjoying using GeoGebra software in the mathematical learning activity.

This above results is consistent with several studies (Kamariah et al., ; Harizon, 2005; Nurihan, 2005) where students showed positive responses towards educational software in understanding mathematics. Harizon (2005) reported that more than 80% of the students have positive responses and perceptions towards element of graphic, text, animation, and presentation in the GSP software design. She also mentioned that the GSP software was easy to be handled, to do calculation, can add with colorful and changeable features of GSP which are able to stimulate the students' mind and thus prolong their memories towards mathematics learning. This is comprehensible with many other researchers that the use of technologies and software could increase students' attitude, perceptions, and motivation in mathematics learning. For example, Kamariah et al. (2010) found that GeoGebra software and V-transformation could be used to motivate secondary school students in teaching and learning mathematics. In addition, a study by Nurihan (2005) revealed that one sample *t*-test has showed that the experimental group with Autograph teaching on Quadratic Function topic has positive effect towards their motivation. In this study, the findings indicated that GTS students showed an overall favorable view towards GeoGebra software integrated in teaching and learning Circle III topic. Hopefully these results will encourage the use of GTS in teaching and learning of mathematics at secondary school in the future.

Conclusion

As conclusion, the findings of this study concluded that there was no significant different on mean scores of Form Four students' test performance between the CTS group and the GTS group in learning Circle III topic. In addition, students showed positive attitudes on using GeoGebra software in learning Circle III topic as this strategy able to help students to learn this topic clearly, and understandable manner. Therefore the findings above could be used as a reference for the policy makers to make a new move so that a proactive measures can be considered to integrate more powerful technology in the mathematics classroom. Therefore, Malaysian educators are encouraged to use this open source dynamic and free software, GeoGebra since it combines ideas of Geometry, Algebra and Calculus into a single easy-to-use package for mathematics teaching and learning.

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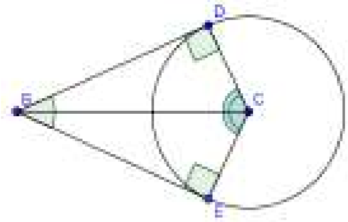
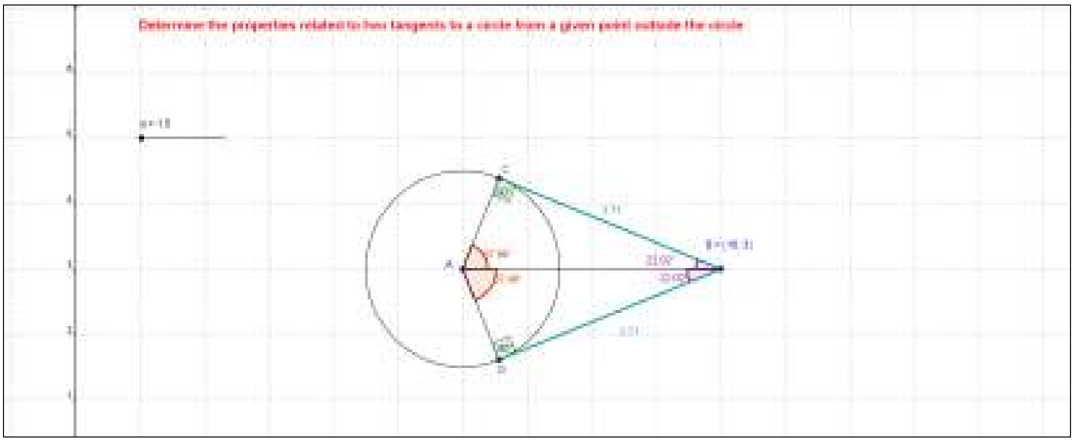
Appendix A. An activity of Conventional Worksheet

<table>
<tr>
<td>


(i) Measure the length of BD and BE by protractor. Is BD equal to BE?
(ii) Measure ∠DBC and ∠EBC by protractor. Is ∠DBC equal to ∠EBC?
(iii) Measure ∠BCD and ∠BCE by protractor. Is ∠BCD equal to ∠BCE?
(iv) Measure ∡CDB and ∡CEB by GeoGebra. Is ∡CDB equal to ∡CEB?
(v) Are the triangle ΔDBC and ΔEBC congruent? Give your reasons.
</td>
<td>
From the activity, it can be concluded that
(a) The two tangents from a point outside the circle to the contact point have the _____ length (=   ).

(b) The line joining the point outside the circle to the centre of the circle bisects the angle between:
(i) The two tangents (∠____ = ∠____)
(ii) The two radii that pass through the contact points (∠____ = ∠____)
Thus, triangles ____ and ____ are congruent.
</td>
</tr>
</table>

Appendix B. An activity of GeoGebra Worksheet



Complete Table 1.3, Table 1.4, Table 1.5 and Table 1.6 by following the instructions below:

Part A:

1. What is the length of BC and BD as you move
   (i) slider α.
   (ii) coordinate B to other point.

What do you observe and compare on the length of BD and BE?
Does the length of BD equal to the length of BE?
Discuss your findings about the relationship between the size of the circle and the length of BC and BD.

Table 1.3

A	BC	BD
1.5		
2		
2.5		
3		
3.5		
Conclusion:		
Intersection point, B	BC	BD
(9, 3)		
(9, 4)		
(10, 3)		
(10, 4)		
Conclusion:		
Summary:		