Students' Performance in Geometrical Reflection Using GeoGebra

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ABSTRACT

Students in this era need to grasp the concept of geometry instead of memorizing formulae. This is important for them to further their knowledge in geometry. The purpose of the research was to determine whether GeoGebra software influences year one students' performance in geometrical reflection. The research utilized an experimental research method. A total of 24 Year One students were randomly selected from an international school. The research used pre-test and post-test. The sample selected were taught and learnt by using GeoGebra software after the pre-test. Then, a post-test was given to them. A paired sample t-test was conducted and the results indicated a significant difference between pre-test and post-test. ANOVA was also conducted to test the influence of gender and ability level on student performance in geometrical reflection. The findings show a significant difference in the scores between genders. Similarly, the results also found statistically significant difference in scores among the three student ability groups. In conclusion, the study implies using GeoGebra enhances students' performance in geometrical studies. Implementing teaching and learning geometry using GeoGebra would help students to explore the concept more in detail and help them to build and develop their geometry knowledge.

Keywords: *geometry, reflection, Geogebra software, primary mathematics*

INTRODUCTION

Geometry is one of the longest-established branches of mathematics and its origins can be traced back through a wide range of cultures and civilizations. During the nineteenth and twentieth centuries, geometry, like most areas of mathematics, underwent a near cataclysmic period of growth. As a consequence, the content of geometry and its internal diversity increased almost beyond recognition (Jones, 2000).

A problem occurs when three-dimensional real-life objects are represented in a two-dimensional computer screen environment. One study by McClintock, Jiang, and July (2002) found GSP provides opportunities to have a distinct positive effect on students' learning of three-dimensional geometry when using the sketching software. Moreover, students have difficulty moving from the three-dimensional world to a two-dimensional world. Experiences that bridge this gap will help them move from concrete to abstract examples of shapes. Reys, Lindquist, Lambdin, Smith, and Suydam (2006) feel that teachers need to emphasize the stages of concrete (manipulatives), semi-concrete (the sketching software), and the symbolic (paper and pencil). Thus, this research study was conducted to ascertain the effects of semi- concrete tools (GeoGebra) on geometry performance.

Technology is a powerful tool for engaging students in learning Mathematics. The importance of using technology in mathematics teaching has been advocated by the National Council of Teachers of Mathematics (NCTM) for many years (NCTM, 1989, 2000). One of the compelling tools that can be used is GeoGebra. GeoGebra is an interactive tool for exploring algebra and geometry. It lets the students explore the mathematics concept. The GeoGebra user interface is flexible and can be adapted to student needs (Dogan, 2010).

Statement Of Research Problem

The literature on student performance in mathematics lesson conducted at school is important to know how effective ICT is in enhancing understanding of mathematics concepts. However, some past research shows several barriers to using ICT in the classroom. Jones (2004) found a number of barriers against ICT integration into lessons, namely: (1) lack of confidence among teachers during integration, (2) lack of access to resources, (3) lack of time for integration, (4) lack of effective training, (5) facing technical problems while the software is in use, (6) lack of personal access during lesson preparation, and (7) the age of the teachers.

Based on Ritchie (1996), schools are not yet effectively implementing instructional technologies despite the increase in the capacity of available educational technology. This study identified lack of administrative support as one of the most critical impediments to integrating instructional technology.

In addition, Dynamic Geometry Software (DGS) use in solid geometry and analytic geometry of space has been neglected. One of the main reasons for this is that two-dimensional Euclidean geometry is still more popular than three-dimensional geometry; hence students often faced difficulties in visualizing three-dimensional figures (Kosa & Karakus, 2010).

Other research studies show that many students have difficulties imagining spatially the analytic geometric task in Euclidian 3D space (E3). Blackboard drawings or handmade transparencies, mainly of questionable quality of perception, are no basis for developing an adequate spatial-geometric understanding in working on tasks of spatial analytic geometry – which does not exclude that students can solve those tasks algorithmically without spatial understanding (Schumann, 2003).

This research attempts to determine whether *GeoGebra Software* affects students' performance in Mathematics lesson. The framework of the research is given in Figure 1.1.

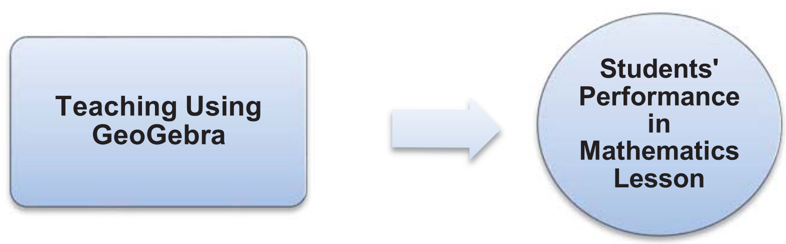

Figure1. **Research Framework.**

LITERATURE REVIEW

Teaching and Learning Mathematics using technology

The National Council of Teachers of Mathematics (NCTM) (Principles and Standards for School Mathematics) (2000) stated, Technology Principle as one of the six principles of high quality mathematics education and has guidelines and supports about the use of technology. In the *Principles and Standards of School Mathematics,* it is stated that *"Technology is essential in teaching and learning mathematics; it influences the mathematics that is taught and enhances students' learning"* (p. 24) and

Teachers should use technology to enhance their students learning opportunities by selecting or creating mathematical tasks that take advantage of what technology can do efficiently and well graphing, *visualizing, and computing* (p. 25).

Furthermore, NCTM suggests that appropriate technology use can facilitate such applications by providing ready access to real data and information, by making the inclusion of mathematics topics useful for applications more practical (e.g., regression and recursion), and by facilitating teachers and students in handling multiple representations of mathematics topics (NCTM, 2000).

Teaching and Learning Geometry using technology

Karakus (2008) planned to determine possible effects of computer-based teaching on student achievement in transformation for geometry subjects. The experimental study found a significant difference in favor of the experimental group. All students in the experimental group achieved high attainment level with computer-based instruction in teaching of transformation geometry. Moreover, this difference becomes more significant and increases for successful students in the subjects of reflection and rotation. It has been observed that computer based instruction increased the experimental group success. However, there was no significant difference between experimental and control groups for low achieving students; According to Ustun and Ubuz (2005), a study comparing traditional educational environments with the dynamic learning environments (Geometer's Sketchpad used) showed a significant difference in favor of the experimental group on the recall (permanence) test. The most important reason for this significant difference was identified as students' explorations of geometrical shapes to see possible connections by manipulating the computer based environment.

Visualization is very important while studying geometry, especially 3D geometry. It can be difficult for students to visualize spatial figures in their mind. The nature of dynamic geometry software provides students with opportunities to learn geometric concepts and to explore and visualize geometric relationships easily. The study aimed at determining whether the three-dimensional computer supported activities designed by dynamic geometry software Cabri 3D for analytic geometry of space can help students develop a better understanding and have a positive attitude or not. Results of the study show that Cabri3D has an important potential to teach analytic geometry of space (Kosa et al., 2010).

Difficulties in Learning Geometry

According to Idris (2006), the lack of understanding in learning geometry often causes discouragement among students, which invariably will lead to poor performance in geometry. She claimed that some factors have been identified as causing difficulties in geometry learning; these are geometry language, visualization abilities and ineffective instruction. She also highlighted that spatial visualization has been linked with geometric achievement because geometry is visual in nature. Geometry is the study of shape and space; it requires visualizing abilities but many students cannot visualize three-dimensional objects in a two-dimensional perspective (Guven & Kosa, 2008).

Learning geometry may not be easy and a large number of students fail to develop an adequate understanding of geometry concepts, geometry reasoning and geometry problem-solving skills (Battisa, 1999; Idris, 2006).

PURPOSE AND RESEARCH QUESTIONS

The purpose of this research was to determine whether GeoGebra software affects students' performance in Mathematics. The research was guided by the following research questions:

1) What are the levels of geometrical reflection among Year 1 students?
2) Is there any significant difference in the post test between genders?
3) Is there any significant difference in post-test between students' ability?
4) Is there any significant difference between the pre-test and post-test scores?

METHODOLOGY

The research utilized the one group pre-test and post-test design. It targeted students in an international school. The research population comprised all students who are studying in Year 1 in international schools. We have used cluster sampling design in this research by selecting students from only one of the year 1 classes from the particular school. A total of 24 students were selected as the research sample. Their age group is 5-6 years old; they are of different ethnicity from Malaysia and internationally such as America, New Zealand, UK, Korea and India; different gender: 12 boys and 12 girls. The students in the class consisted of three groups namely Extension, Core and Support. Some 6 students from the Extension group are those who always achieved excellent performance in Mathematics, whereas 12 students are in the Core group which is known as an intermediate group. Lastly, the Support group students consist of 6 students who need some extra guidance in completing their tasks or sometimes they might not achieve their objectives. All the students were given a task to do in their sketchbook after Reflection was taught using GeoGebra software.

The task used in this study consists of the drawing of buildings by the student. Then, students were asked to reflect the object of the buildings they drew.

All the students, consisting of 12 girls and 12 boys were given a pre-test before being introduced to GeoGebra software. They were taught what reflection is using the traditional method and asked to draw the reflection (pre-test). After the pre-test, the students were introduced to the GeoGebra software during their ICT lesson. The students listened to the steps explained using Smart board. Three students were selected to try out the reflection. The students were exposed to the knowledge of what reflection is and how it is used in our lives and where it happens. The students then went to their own PC to complete the activity given. Then, they were given the post-test a few days later.

The pre-test and post-test results were analyzed using the SPSS software.

RESULTS

To answer the research question, "What are the levels of geometrical reflection among Year 1 students?"

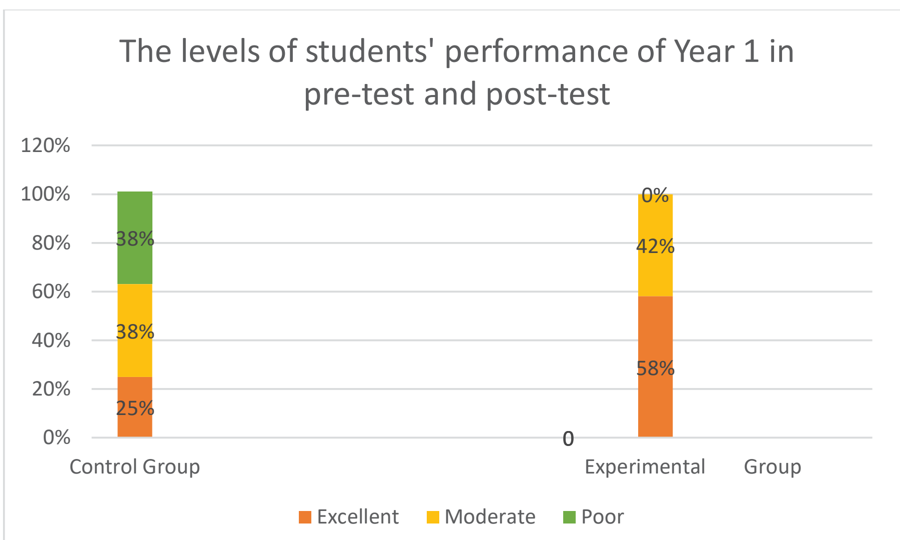

Figure 2. **The comparison of pre-test and post-test results of geometrical reflection for Year 1 students**

Figure 1 shows that, in the control group Moderate and Poor have the highest percentage 38%. The students from different group such as core and support groups are mostly in the Moderate and Poor category. The students proved that they do not prefer traditional method because it could not fulfil all the requirements in drawing. The least is Excellent which is 25% only. Some students from the extension group can adapt to traditional method.

However, in the experimental group, the highest percentage is 58% for Excellent, 42% Moderate and 0% Poor. It shows in post-test students did better than in pre-test. There is none in the category Poor which shows the students are able to learn the concept of Reflection and could carry out the task given successfully.

Table 1. Tests of Normality

	Gender	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
Score	Female	.351	12	.000	.668	12	.000
	Male	.153	12	.200*	.920	12	.282

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

To fulfil the requirement of ANOVA test normality test had been conducted. Table 1 shows the results for tests of normality. Since the number of participants was below 50, Shapiro-Wilk test was used to check the normality. The *p*-value for male is .282 more than .05 which means the assumption of normality was not violated. Table 7 shows the tests of normality.

Table 2. Tests of Normality

	Ability	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
		Statistic	Df	Sig.	Statistic	df	Sig.
Score	Support	.186	6	.200*	.932	6	.595
	Core	.191	12	.200*	.876	12	.078
	Extension	.455	6	.000	.638	6	.001

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

The *p*-value for Support is .595 which is more than .05 indicating that the data were approximately normal in distribution.

To answer the second research question of "Is there any significant difference in the post test between male and female students?"

Table 3. Descriptive Statistics Score

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
Female	12	86.00	8.356	2.412	80.69	91.31	68	92
Male	12	68.33	13.506	3.899	59.75	76.91	50	88
Total	24	77.17	14.215	2.902	71.16	83.17	50	92

The descriptive table, Table 3, provides some very useful descriptive statistics, including the mean, standard deviation and 95% confidence intervals for the dependent variable (Score) for each separate group (Female and Male), as well as when all the groups are combined (Total). The mean score for Female is 86.00 that is higher than the male score of 68.33. The standard deviation for Female is 8.356 while the standard deviation for male is 13.506.

Table 4 Independent Samples Test

		Levene's Test for Equality of Variances		*t*-test for Equality of Means						
		F	Sig.	*t*	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Score	Equal variances assumed	5.689	.026	3.85	22	.001	17.667	4.585	8.158	27.175
	Equal variances not assumed			3.85	18.34	.001	17.667	4.585	8.047	27.286

An independent samples *t*- test was conducted to determine if the mean of male group differs from that of the female group. The *F* test and *p* value of Levene's Test for Equality of Variances was reviewed to determine if the equal variances assumptions have been met. According to Levene's Test, the homogeneity of variance assumption of was *F*= 5.689, *p* = .001.

Based on Table 4, we see that the significance (2-tailed) value is .001. This value is less than .05. Thus, there was a statistically significant difference between the mean of male and female group on the score of geometrical reflection. An independent-samples *t*-test was conducted to determine the significance of difference between male and female in the geometrical reflection score. There was a significant difference in the scores for male (*M* = 68.33, *SD* = 13.506) and female (*M* = 86.00, *SD*=8.356) conditions; *t* (22) =3.85, *p* = .001.

The mean difference value of 17.667 shows that in the population from which the sample is drawn, the female students (mean score = 86.00) scored better compared to male students (mean score = 68.33). The mean value for both groups can be seen in Table 4. To answer the third research question, "Is there any significant difference in post achievement between students' abilities?"

Table 5 Descriptive Scores

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
Support	6	59.67	7.941	3.242	51.33	68.00	50	70
Core	12	80.17	11.676	3.371	72.75	87.59	54	92
Extension	6	88.67	4.320	1.764	84.13	93.20	80	92
Total	24	77.17	14.215	2.902	71.16	83.17	50	92

Table 5 provides some very useful descriptive statistics, including the mean, standard deviation and 95% confidence intervals for the dependent variable (Score) for each separate group (Support, Core and Extension), as well as when all groups are combined (Total). The results show that the mean for Support is 59.67, Core is 80.17 and the highest score is for the Extension group (88.67). On the other hand, the standard deviation was the highest for the Core group (11.676) followed by Support with 7.941 and Extension with 4.320.

Table 6 ANOVA Score

	Sum of Squares	df	Mean Square	*F*	Sig.
Between Groups	2739.000	2	1369.500	15.070	.000
Within Groups	1908.333	21	90.873		
Total	4647.333	23			

Table 6 shows a one-way between groups analysis of variance conducted to explore the effect of GeoGebra on Geometrical Reflection. Participants were divided into three groups according to their ability (support, core and extension). There was a statistically significant difference at the $p < .05$ level in scores for three ability groups F (2, 23) = 15.070, $p < .05$. Post-hoc comparisons using the Tukey HSD test indicated that the mean score for Support group (M = 59.67, SD = 7.941) was significantly different from that of the Core group (M = 80.17, SD = 11.676) and the Extension group (M = 88.67, SD = 4.320).

Table 7 Multiple Comparisons

Dependent Variable: Score Tukey HSD

(I) Ability	(J) Ability	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Support	Core	-20.500*	4.766	.001	-32.51	-8.49
	Extension	-29.000*	5.504	.000	-42.87	-15.13
Core	Support	20.500*	4.766	.001	8.49	32.51
	Extension	-8.500	4.766	.199	-20.51	3.51
Extension	Support	29.000*	5.504	.000	15.13	42.87
	Core	8.500	4.766	.199	-3.51	20.51

* The mean difference is significant at the 0.05 level.

As shown in Table 7, most of the p-values were less than .05. For this reason, we can conclude that the Extension and Core groups were not significantly different. However, the other 2 groups were significantly different from one another. This means that the Support and Core group were significantly different. Similarly, the Support and Extension group scores were statistically significant.

To answer the last research question, “Is there any significant difference between the pre-test and post-test scores of the experimental group?”

Table 8 Paired Samples Test

		Paired Differences					*t*	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	Pretest - Posttest	-14.87500	10.71493	2.18718	-19.39952	-10.35048	-6.801	23	.000

A paired samples *t*-test was conducted to determine the significant difference between pre-test and post-test in using GeoGebra on students' performance. There was significant difference in the scores for the GeoGebra group (M = -14.875, SD = 10.715), t (23) = -6.801, p = .00. These results indicate that the students performed better after using GeoGebra on Geometrical Reflection.

DISCUSSION AND CONCLUSION

The findings of the study indicate that using of GeoGebra software in teaching and learning will promote good learning outcome in geometric transformations especially in the topic of reflection. There is a significant difference between pre-test and post-test in using GeoGebra on students' performance in the paired samples *t*-test conducted. The results indicate that the students did better after the interventions using Geogebra software. The students can have clear understanding of reflection by reflecting the objects in the software. Additionally, they also could explore and grasp the concept of reflection. Thus, they manage to do well in their post-test compared to their pre-test.

Moreover, the study also investigated the role of gender (male and female) on students' performance and the results indicated a statistically significant difference. The results indicated that girls did better than boys probably because girls have high interest in exploring the software on the reflection topic. They also might link the concept well that they have learnt when they do it manually (using pencil and paper). However, boys were more focused on the software activity and showed less interest in doing reflection manually.

Furthermore, ANOVA test was also conducted to find if there is any significant difference in post achievement and ability of the students and there was a statistically significant difference at the $p < .05$ level in scores for three ability groups F (2, 23) = 15.070. The results meant that all the ability groups are keen to learn the topic using GeoGebra software. The software is suitable and user friendly for all the ability groups.

The findings support Ustun and Ubuz (2005); the results of their study comparing traditional educational environments with the dynamic learning environments (Geometer's Sketchpad used) showed a significant difference in favor of the experimental group on the recall (permanence) test.

This study found a positive effect by teaching Reflection using GeoGebra Software on students' performance in mathematics lessons. The finding supports NCTM (2000). This finding also supports the view of Doğan and İçel (2010) that GeoGebra is found to be very efficient in mathematics education and can be used effectively both in teacher training and student learning. It can be said that computers can lead to improved teaching and learning of mathematics by establishing possible benefits of software. The finding also supports the view of Dogan and Icel on effectiveness of GeoGebra as an interactive geometry system.

Based on the present research findings, both traditional method and using GeoGebra Software to teach Reflection shows positive effect. However, it can be concluded that using GeoGebra software to teach Reflection shows better results than the traditional method. The findings show none of the students at the level of Poor (do not fulfill most of the properties of reflection). The students who did not manage to do well in pre-test, could do better in the post-test. Moreover, some students who were at the level of Moderate (fulfill partially the properties of reflection) in pre-test, could manage to improve themselves and obtain the level of Excellent (fulfill all the properties of reflection) in post-test. In overall, all the students could draw the image or the reflection of the object to satisfy the properties of Reflection with understanding of the concept in the post-test. However, using traditional method, only the Extension group students could fulfill all the properties of reflection. Core students could only score up to Moderate and some scored Poor together with the support group.

Students often have difficulties in visualizing three-dimensional figures (Kosa & Karakus, 2010); the difficulties were tackled by implementing usage of GeoGebra software in learning Reflection in this research. The children visualized the object in 2-D and 3-D very well. They could imagine the 3-D picture and mostly can draw by reflecting it.

Idris (2006) stated that the lack of understanding in learning geometry often causes discouragement among the students, which invariably will lead to poor performance in geometry. However, the study proves that GeoGebra software gave students a clear understanding on the topic of geometric transformations because the students could perform better in their post-test compared to their pre-test.

In conclusion, the students can achieve the learning objectives of geometric transformations in reflection by using GeoGebra software in learning. Research suggests that teachers should use the software in teaching and learning of geometric transformations since it is useful. For further research in future, research can be conducted by testing on a larger sample. The research also can employ a longer period of intervention. Research also can be focused on different topics in geometric transformations using GeoGebra.

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DRAW A PICTURE IN THE MIRROR

Description	The students insert picture in this software and try to see the reflection of the picture. Then, they were asked to draw the picture on their own in their IPC topic book.
Grade	Year 1
Age Group	5- 6 years old
Total Time	60 minutes
Standards	**Draw a Picture in the Mirror** Create a square and see the reflection. Then, insert their favorite pictures and see the reflection in *Geogebra*. Draw the pictures of buildings near the beach with reflection on the beach in their IPC topic book.
Geogebra Skills	The topic reflection is appropriate to be taught using *GeoGebra Software* where the students of this age group can see the clear picture of reflection and can understand the concept. The students will use the skills learnt earlier such as inserting pictures and constructing polygons to do this activity.
Mathematical Background	The students will be introduced to a new topic of reflection.

Step 1

Students will open *GeoGebra software* from the desktop.

Step 2

Students will click “Show or hide the axes” to make both the axes disappear. Then, they will be asked to click “Show or hide the grid” to make the grid disappear on the window as well.

Step 3

Students will be asked to click on the regular polygons and create a square. Then, to label the points students will choose one of the points and click “Set Label Style” to select “Name” as shown in the following Image 1. The steps will be repeated for other points also.

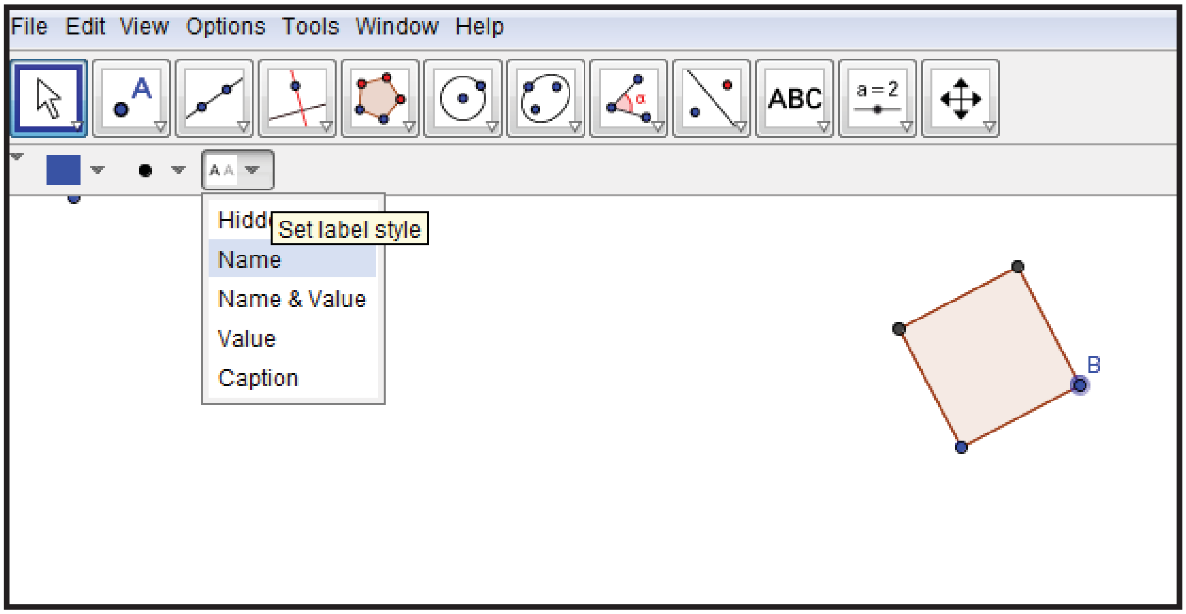

Image 1

Step 4

Students will be asked to construct a line. Next, they will click one of the points from the square and click; click the line constructed and click "Reflect about Line". The steps will be done for all the points like Image 2.

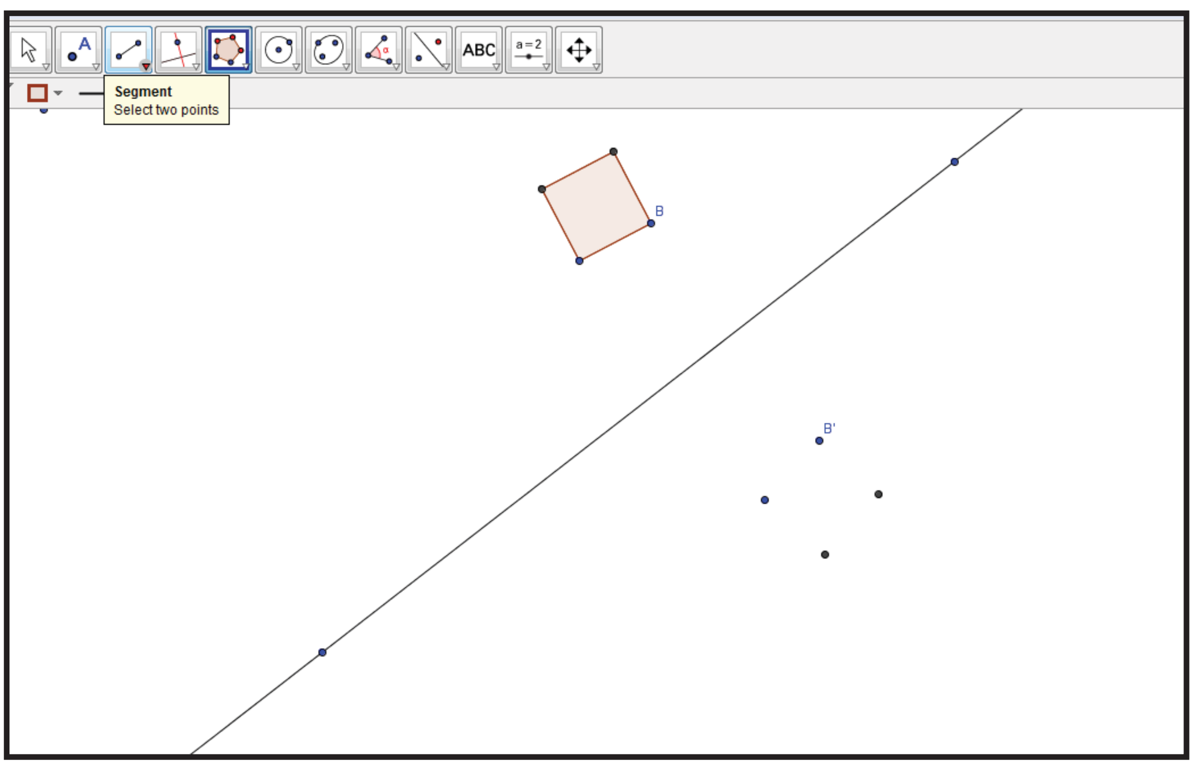

Image 2

Step 5

The points are then connected by the segments.

Step 6

Students will continue by inserting different pictures. At this time, they just need to click the picture and followed by the line only because the option "Reflect about Line" is already selected. The students will repeat the steps by adding other pictures. The example Image 3 as below;

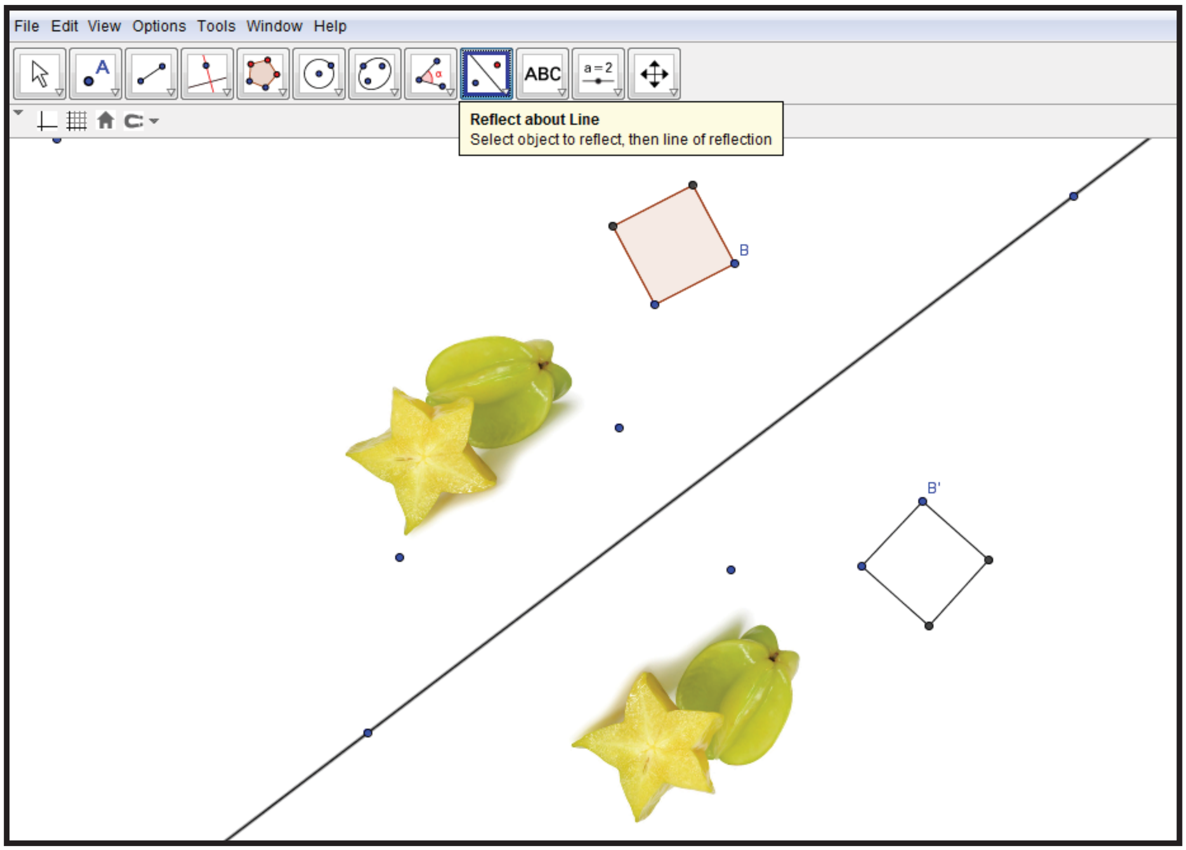

Image 3