Utilization of Computer Technology in Learning Transformation

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Abstract—The integration of technological tools especially computer software may contribute to creating powerful learning environments in numerous ways especially in the teaching and learning of mathematics. Utilization of computer technology to enhance students understanding of mathematics has been widely practised. Various types of dynamic mathematical software such as Geometer's Sketchpad, Autograph and the Graphing Calculator have been utilized for the learning of mathematics in Malaysian secondary schools. However, the use of an open source software in teaching and learning mathematics is still new in Malaysia. This paper compare the effectiveness of an open source software, GeoGebra and two coursewares (e-transformation and V-transformation) developed by the researchers for learning transformation. A total of 101 secondary school students participated in the study. They were randomly assigned into three separate groups. Each group underwent instruction utilizing one of the three coursewares. Findings showed that significant differences existed between the pre and post test of the performance scores of each group that used GeoGebra, e-transformation and V-transformation. However, there was no significant difference in the post test performance scores of the three groups. Further analysis also showed that there was no significant difference in the post test scores of each of the three topics included in the software. These findings had shown that computer technology was effective in teaching mathematics at Malaysian secondary school level. However, the findings did not indicate which software was more suitable to be used in the teaching and learning transformation.

Key-words: - GeoGebra, Transformation, Reflection, Rotation and Mathematics.

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I. Introduction

In recent years computer technology has progressed quickly and the personal computer and the internet have become closely linked to human life, more so in education [8]. Most countries have begun to integrate the use of Information, Communication and Technology (ICT) in their educational system. The Malaysian Government through the Ministry of Education and Ministry of Higher Education also have embarked on the integration of ICT in the Malaysian educational system. ICT has the potential means to innovatively change and motivate students to be active and not as passive listeners [14]. The use of computers in teaching and learning has become a catalyst and as an impetus to positively reform and change the approach to teaching and learning, especially for mathematics courses. Computers have been said to be useful as tools to assist students in their exploration and discovery of concepts in the problem solving process [2]. However, [2] also stated that computers can only be used as an aid in teaching and learning but not as the purpose of education.

There are many mathematical software in the market such as Mathematica, Matlab, Maple V, Geometers' Sketchpad, Autograf, Graphic Calculator and others. These software tools can provide powerful symbolic and numerical calculations, can produce quick calculations and also can assist students in the abstract mathematical concepts. Numerous research results suggest that these software packages can be used to encourage discovery, experimentation and visualization in traditional teaching of mathematics [7]. However, researchers suggest that, for the majority of teachers, the main problem is how to provide the technology necessary for the successful integration of technology into teaching [19]. Research also indicates that solely providing technology to teachers in the majority of cases is insufficient for a successful integration of technology into teaching practices [6]. Besides that, the use of mathematical software such as the above mentioned, require a large expenditure in getting licensure should the government decide to implement these software tools in schools.

The existence of open source software tools can overcome this problems. Now there are companies and individuals who develop mathematics software and disseminate them for free to the public. Open source software tools have become increasingly popular among computer users who seek an

alternative to the paid software tools. Browsing through the search engines opens one to an array of mathematical software tools which can be downloaded and used free of charge. Mathematical software such as Maxima (http://maxima.sourceforge.net), Scilab (http://www.scilab.org), AXIOM (http:axiom. axiom-develepor.org), YACAS (http://yacas. sourceforge. net), MuPad (http://www.mupad.de), GEOGEBRA (www.geogebra.org), Geo Net (http://geonext. uni-bayreuth.de), FreeMat (http:// www.freemat. sourceforge.net), SAGE (www.sagemath.com) and others are ready to be downloaded and used in teaching and learning. In addition, teachers who have skills in programming can also develop their own mathematical software for their students' use. Courseware such as the latter has advantages as it is being specifically developed for their own students. In Malaysia, the idea of using open source mathematics software is still new compared to other countries such as Europe and the United States. At school, most Malaysian teachers tend to use in their classes only the software tools supplied by the Ministry of Education. However, these software tools are more towards multimedia-based teaching where difficult concepts are explained through the use of animation, video and audio. Thus, teachers will adopt the software without actually looking into the needs of their students. In addition, the software tools are used for drill practices to enhance students' skills in mathematics. Mathematic software tools such as Geometers Sketchpad, Graphic Calculator, Mathematica, Matlab and others require teachers to guide students to explore and to achieve the objectives. Thus, teachers need to take time to explore each software tool first, so that it can really be beneficial to the students. However, having to take time to learn and master the tool will deter the teachers to use it compared with the software supplied by the Ministry of Education which are more towards multimedia based

Many studies have been conducted to determine the suitability or effectiveness of the use of computer software in teaching and learning mathematics. The results of using computers to assist in the instruction of mathematics have been mixed. For example, studies by [13] compared the use of an Ethnomathematics software and the traditional method in learning. The findings indicated that the test scores between the two groups significantly differed with students who used the Ethnomathematics software achieving higher scores. Research by [18] showed that teaching and learning mathematics utilizing the graphing calculator was found to be instructionally efficient significantly, compared to the conventional and Autograph software. Mean while, findings by [12] indicated that the use of Geometers Sketchpad (GSP) induced higher mathematical thinking process amongst the GSP group. This findings showed that the use of GSP had an impact on both mathematical thinking process and performance. On the other hand, research findings also indicated that there are no advantages in terms of students' performance using technological tools in teaching and learning mathematics. For instance, [15] and [16] reported that there were no significant differential effect between conventional teaching and the use of graphing calculators. Research by [9] also found that there was no significant difference in college students' achievement between those who attended the Introduction to Statistics course using the traditional method compared to the ones who used computers. Studies by [21] using electronic books for Pre-calculus courses at the university showed there was no significant difference in pre-test scores, but was significant in the post-test performance. [20] also compared students' achievement between those who attended mathematics tutorial classes by lectures and also by computer. Results showed that there was no significant difference in the students' achievement between both groups. Another study by [1] on students using web based interactive tutorial and the traditional method for a mathematics course found that both groups significantly differed between the pre and post tests but were not significantly different on the post test performances between both groups. Meanwhile, [4] introduced a computer assisted problem solving system called MATH CAL. The effectiveness of the system was tested by an experimental research on fifth grade students. Pre and post test results indicated that students in the experiment group showed significantly higher improvement than the control group on the post test. [3] compared the effectiveness of computer-based instruction to traditional instruction. Pre and post tests were given to determine the effect of using Geometer Sketchpad software versus instruction that utilized strictly paper and pencil activities. The report showed that the experimental group scored significantly higher on the post test than the control group.

Most studies discussed above were referring to the use of either purchased commercially prepared mathematical software tools or handheld technology. Studies conducted on the use of open source software are rare. This is because many educators still hesitate to use this type of software in their classes. Discussions on the effectiveness and benefits of the use of open source software only tend to appear basically on forums, blogs, wikis and so forth, without going through proper rigorous scientific research. The discussions are more on personal views by users who have been using the software

II. PURPOSE

The purpose of this study was to investigate students' performance scores using three coursewares, namely, GeoGebra, e-transformation and V-transformation in the learning of mathematics by Form two secondary school students' on Transformation.

a. GeoGebra

GeoGebra is an open source software under General Public License (GPL) and available for free at www.geogebra.org. This software combines geometry, algebra and calculus into a single ease-to-use package for teaching and learning mathematics from elementary to university level [11]. GeoGebra has the ability to deal with variables for numbers, vectors and points, finds derivatives and integrals of functions and offers commands like Root or Extremum values. GeoGebra tries to combine the ease-to-use of dynamic geometry software with the versatile possibilities of CAS [10]. These two views are characteristics of GeoGebra used in this study (refer Diagram 1 and 2).

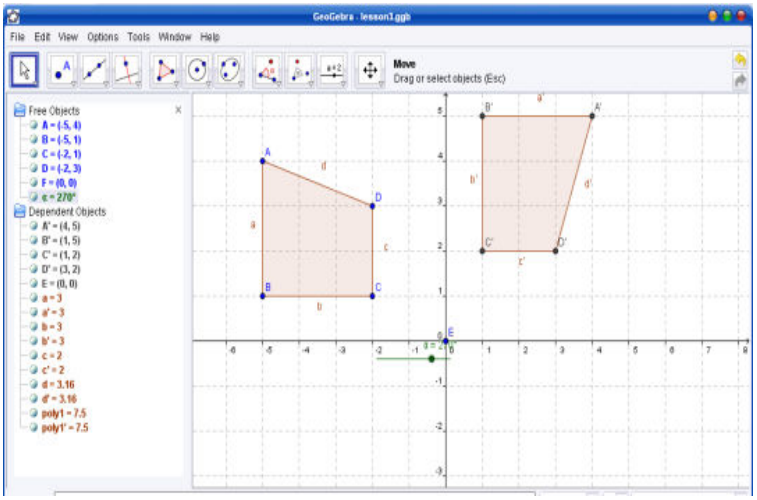


Diagram 1: Screenshot of Translation topic in GeoGebra

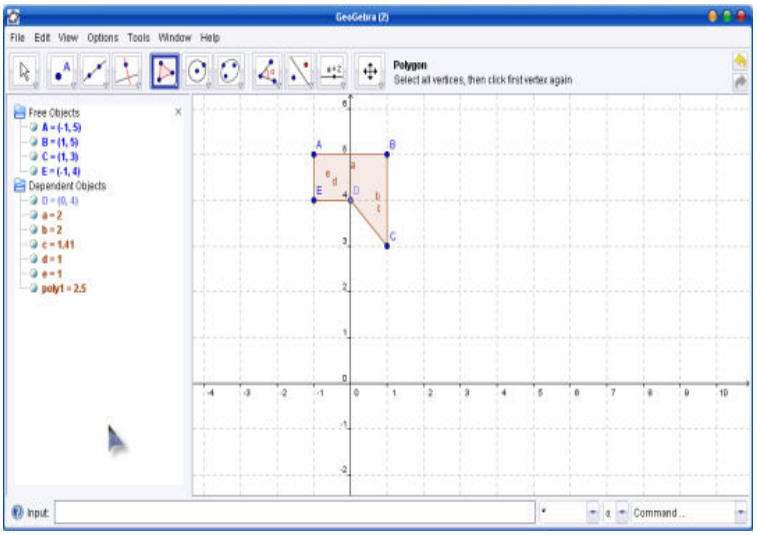


Diagram 2: Screenshot of Rotation topic in GeoGebra

Like other mathematic software, GeoGebra also has several advantages. The advantages of using GeoGebra according to [7] are:

a) GeoGebra is more user-friendly. GeoGebra offers easy-to-use interface, multilingual menus, commands and help compared to a graph calculator;
b) GeoGebra encourages students` projects in mathematics, multiple presentations and experimental and guided discovery learning;
c) Students can personalize their own creations through the adaptation of interface (e.g. font size, language, quality of graphics, color, coordinates, line thickness, line style and other features);
d) GeoGebra is created to help students gain a better understanding of mathematics by manipulating variables. This can be done easily by simply dragging “free” objects around the plane of drawing, or by using sliders. Students can generate changes using a technique of manipulating free objects, and then they can learn how the dependent objects are affected;
e) Lecturing should be replaced by a task oriented interactive classroom. The primary role of teaching is not to lecture, explain, or otherwise attempt to "transfer" mathematical knowledge, but to create situations for students that will foster their making the necessary mental constructions. In that sense, GeoGebra provides a good opportunity for cooperative learning either in small groups, or whole class

interactive teaching, or individual/group student presentations; and

f) GeoGebra stimulates teachers to use and assess technology in visualization of mathematics; investigations in mathematics; interactive mathematics classes on site or at a distance.

b. E-transformation

The second courseware used in this study was developed by the researchers. E-transformation was developed by using a software called Lecture-Maker. E-transformation consisted of a video showing a teacher explaining the transformation topics followed by animations to help the students understand the topics. From this, students could experience learning transformation with the combination of a teacher's explanation and also computer animation. This situation was similar to the traditional classroom except that it had been digitalized.

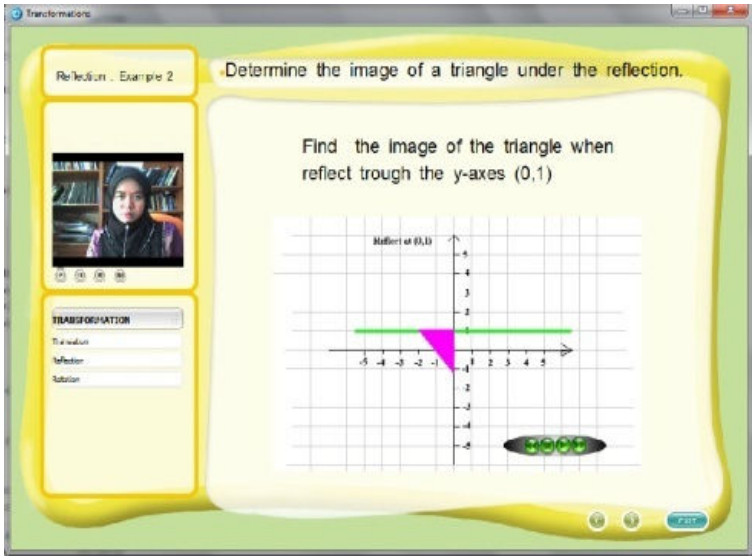


Diagram 3: Screenshot of Translation Topic in e-transformation

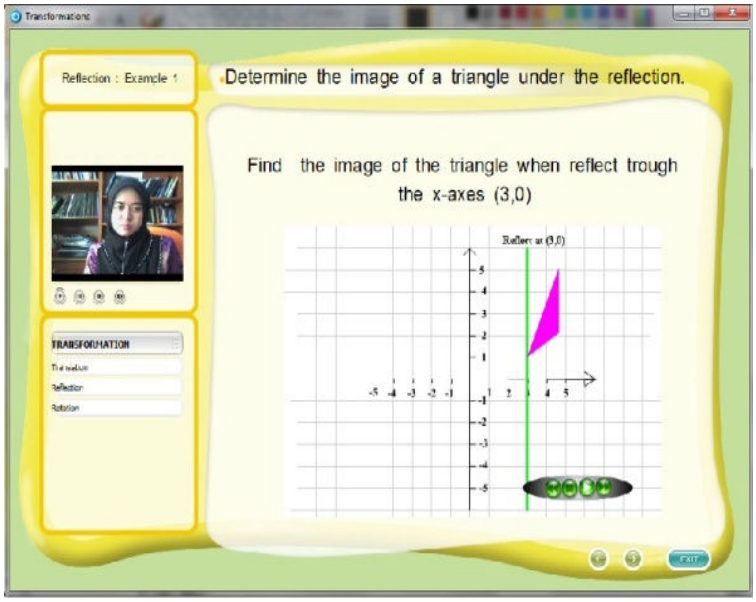


Diagram 4: Screenshot of Reflection Topic in e-transformation

c. V-transformation

V-transformation is also a mathematical courseware developed by a group of researchers. It was developed using Macromedia Flash and also Lecture-Maker. Just like the other coursewares, V-transformation also consisted of three main topics in Transformation which are reflection, translation and rotation. This courseware was developed based on a preliminary study among some specialist teachers to identify problems faced by students on Transformation. From this study, the students found that they were having difficulties to visualize the concepts of Transformation. The visualization that is possible with today's dynamic software enables the student to see and explore mathematical relations and concepts that are difficult to "show" in the past, prior to the existence of technology [7]. The meta-analysis of most research in the area of instructional technology in education shows that students who use technology in their learning had positive gains in learning outcomes over students who learned without technology [22].

From here, the researchers stressed that the elements of visualization is an important factor when explaining important concepts on this topics. So, V-transformation is a mathematics courseware specialized to help students to visualize the concept of transformation by using animations. Exercises were given after students completed each topic to test their understanding of each topic discussed.

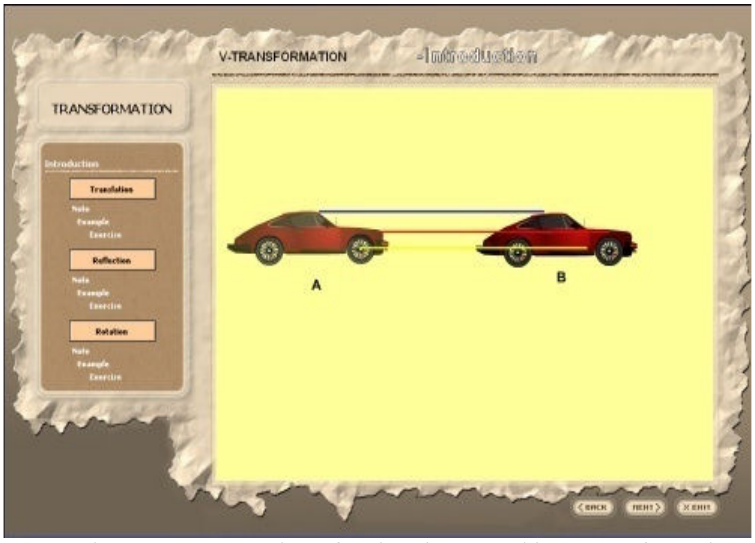


Diagram 5: Screenshot of Animations Used in V-transformation

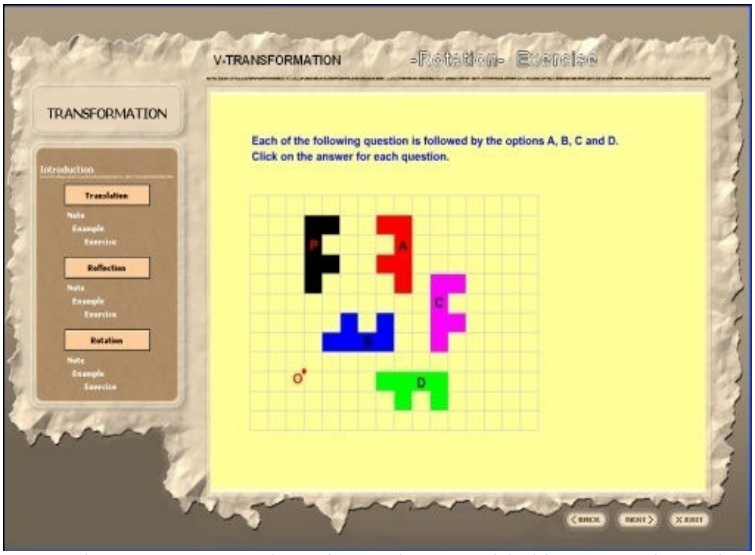


Diagram 6: Screenshot of Exercises Provided in V-transformation

III OBJECTIVE OF THE STUDY

Specifically, the objective of this study was to compare the effects of utilizing the three technologies (GeoGebra, e-transformation and V-Transformation) on various performance measures in the learning of transformation topics amongst Form two secondary school students.

Research hypotheses of this study are:

i. There is a significant difference on performance scores on pre and post tests for the group that used GeoGebra in learning the transformation topics.
ii. There is a significant difference on performance scores on pre and post tests for the group that used e-transformation in learning the transformation topics.
iii. There is a significant difference on performance scores on pre and post tests for the group that used V-transformation in learning the transformation topics.
iv. There is a significant difference on pre test performance scores for groups using GeoGebra, e-transformation and V-transformation in learning the transformation topics.
v. There is a significant difference on post test performance scores for groups using GeoGebra, e-transformation and V-transformation in learning the transformation topics.
vi. There is a significant difference on performance scores on each topic (transformation, reflection and rotation) for groups using GeoGebra, e-transformation and v-transformation in learning the transformation topics

IV METHODOLOGY

A. Design of the Study

An experimental design was used for this study with students selected at random and assigned into three groups. One group used GeoGebra while the other two groups used e-transformation and V-transformation, respectively. In this study, there was no control group employed since all three groups underwent computer- based learning. Four phases were conducted for all the three groups, namely:

1) Testing phase for the Pre Test,
2) Introduction to Software (GeoGebra, e-Transformation and V-transformation);
3) Integrated teaching and learning using respective software and a Learning Activity Module; and
4) Testing phase for the Post Test.

B. Population and Sample of the Study

The target population of this study was Form Two students in National Secondary School in Malaysia and the samples were purposively taken from a school. Initially 116 students were involved in the study. They were assigned randomly into three groups, whereby the first group followed the GeoGebra mode of learning, the second group used e-transformation and the last group went through V-transformation. However, by the end of the experiment, due to mortality threat, the results of only 101 students from the three groups were analyzed. Finally, the total number of students in group one was 40 students, group two was 30 students and group three was 31 students. All the activities were done in three different computer laboratories in the school.

C. Procedures

The detail explanations of the four phases conducted in this study are as the following:

First Phase

In the first phase, students from all three classes were gathered in a mini library. They were random assigned into three groups, resulting in Group 1 having 40 students, Group 2 and 3 each with 38 students. Then, every student from each group was given a file in three different colors which were red, yellow and blue. Similar colored file contained similar materials that were to be used for each group. They were then given the pre test questions to answer.

Second phase

In the second phase, all the treatment groups were first introduced to the respective coursewares. Students in the GeoGebra group were each provided with one computer installed with GeoGebra software. Students in Group 2 were each provided with a CD-ROM which contains e-transformation courseware while students in Group 3 were each provided a V-transformation CD-ROM. In this phase, the students were required to explore and be familiar with the courseware given and its functions.

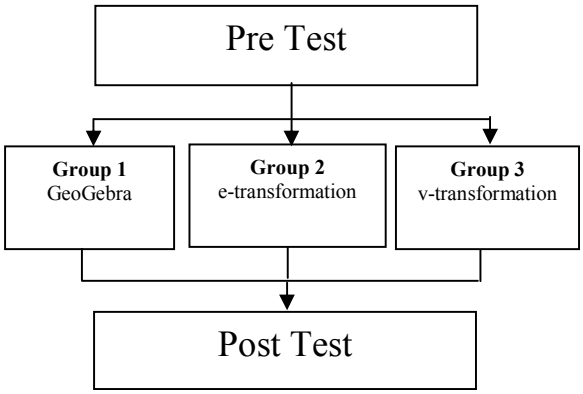
Third phase

In the third phase, students were introduced to the basic concept of Transformation. In this phase, all students were taught using the constructivist approach during the teaching and learning process, especially for the first group. After the exposure to the basic concept of Transformation, the students were required to use exploratory and discovery learning for each the three subtopics using the courseware provided following the Learning Activity Module. During this teaching and learning phase, students were given assessment questions to evaluate the extent of short term learning. However, for Group 1, a teacher was assigned to guide students throughout the lessons. Every student in each group needed to complete all the three subtopics which were rotation, translation and reflection.

Fourth phase

After all the students in the three groups completed the transformation activities module, they were given a post test. For this, nine questions were posed, three for each of the three subtopics tested. The students were given 40 minutes to answer all the questions. The post test was conducted in the respective computer laboratories.

The illustration of the procedural flow is shown in the diagram that follows.



V. FINDINGS

A. Effects of GeoGebra on Performance Scores for Pre and Post Tests

For the group that used GeoGebra, analysis of the performance scores for pre and post tests is by using Wilcoxon T. Research findings indicate that there are significant differences in performance scores for post test (Mdn = 31.00) compared to the pre test (Mdn = 25.00), z = - 2.85, p =.004 <.05, r = -0.45. The results showed that students who learned about transformation using GeoGebra showed increase in their performance after they used it. However, the effect size is medium [5].

B. Effects of e-transformation on Performance Scores for Pre and Post Tests

For the second hypothesis, analysis based on Wilcoxon T showed that there are significant differences in performance scores for post test (Mdn = 25.00) compared to the pre test (Mdn = 20.00), z = - 2.76, p = .006 < .05, r = -0.50. This showed that students using the e-Transformation could increase their performance scores. Meanwhile, the effect size is big [5].

C. Effects of V-transformation on Performance Scores for Pre and Post Tests

For Group 3 which used V-transformation, analysis using Wilcoxon T based on their performance scores for pre and post tests indicate that there is significant differences in performance score for post test (Mdn = 28.00) compared to the pre test (Mdn = 19.00), z = - 3.903, p =.045 <.05, r = -0.36. The results illustrated that students in this group showed increase in their performance scores after they used the V-transformation CD-ROM . However, the effect size is medium [5].

D. *Effects of GeoGebra, e-transformation and V-transformation on Overall Performance scores for Pre Test*

To answer the fourth hypothesis, Kruskal-Wallis test was conducted on pre test performance scores for the groups using GeoGebra, e-transformation and V-transformation. Research findings showed that no significant difference existed in pre test performance scores for all three groups, $\chi^2(2)=0.412$, $p > .05$. This showed that based on the pre test scores, students from all groups started at the same level.

E. *Effects of GeoGebra, e-transformation and V-transformation on Overall Performance Scores for Post Test*

Next, the fifth hypothesis, Kruskas-Wallis test was also conducted on the performance scores for the groups using GeoGebra, e-transformation and V-transformation. Findings also indicated that there was no significant difference in the post test performance scores for all three groups, $\chi^2(2)=0.438$, $p > .05$. This finding showed that students who used GeoGebra, e-transformation and V-transformation performed just as well on the post test scores, regardless of which courseware was used to learn Transformation.

F. *Effects of GeoGebra, e-transformation and V-transformation on each topic (reflection, translation and rotation) tested*

More detailed analysis was conducted according to each subtopic in the post test. Three subtopics tested were reflection, translation, and rotation. For this purpose, the Kruskas-Wallis test was conducted. Research findings indicated that for reflection, test analysis did not show any significant difference in performance scores between GeoGebra, e-transformation and V-transformation groups, $\chi^2(2)=0.734$, $p > .05$. Similarly, for translation subtopic, findings showed no difference existed between the three groups $\chi^2(2)=0.148$, $p > .05$. Mean while, for rotation subtopic, findings also indicated that there was no significant difference in the performance scores for all three groups, $\chi^2(2)=0.296$, $p > .05$. Findings of this study show that for each subtopic included in the post test, students who used GeoGebra, e-transformation and V-transformation were found to have the same skills when answering questions related to reflection translation, and rotation.

VI. DISCUSSION

Educators need to make their teaching and learning mathematics easy for students to learn and enjoy in the class. Educators also need to help students to develop their confidence and ability to solve mathematics problems. By preparing them to do well in mathematics and be able to use the available technology in order to have a better understanding of mathematics, could help to prepare students to compete and function in this high-tech world. The integration of mathematical software in teaching and learning is important due to its ability to do quick calculations and also helping students to visualize difficult and abstract

mathematical concepts. Various mathematical software tools like Mathematica, Maple, Geometers' Sketchpad, Autograf and others are now available in the market. However, users need to purchase this software if they decide to use it. However, the existence of mathematical open source software can resolve this problem. There are many open sources mathematical software which can be downloaded for free from various sites on the Internet. However, the ability and effectiveness of each of these softwares has not yet been fully explored. In addition, researchers or educators can also be encourages to develop their own software specifically targeted for their students' needs.

In this study, GeoGebra as a form of open source software was used and the effectiveness of this software was compared to two other coursewares developed specifically for the purpose of the study (e-transformation and V-transformation). In this study, students who used the three softwares, namely GeoGebra, e-transformation and V-transformation showed better performance in terms of performance scores between pre and post tests. This shows that the use of technology can have a positive effect on student achievements. However, findings did not show any significant difference between students who used the GeoGebra software, the e-transformation courseware and the V-transformation courseware. Similarly, further analysis carried out based on each topic on the post test also did not show any significant difference between the gropus'performance scores in the subbtopics transformation, reflection and rotation. Findings of this study matched the study conducted by [1], [3], [4], [9], [15], [16], [19] and [21].

VII. Implication of the Study

Technology is essential in teaching and learning mathematics. The result of this study could have an implication in the teaching and learning of mathematics in schools. This study shows that there is improvement on students' achievement scores for students who are using open source software and also those using self-developed coursewares. However, this research does not show any evidence which software is better. Further studies need to be undertaken to identify other factors that may assist in the integration of technology in teaching and learning of mathematics which can benefit educators and students alike. Students also need ample time to get used to the software before they can really benefit from it.

Educators also need to consider using mathematical open source software in their teaching and learning of mathematics. Even though the software is not well-known compared to more established mathematical software such as Mathematica, Maple, Geometers' Sketchpad, but findings from this study shows that students performed significantly better after using the open source software too. There are a lot of open source softwares which can be downloaded for free from the internet. These softwares vary from calculus to algebra and statistic at all educational levels. Since these are open source materials, and they are downloadable for free, even students also can also use them from home as a medium to learn mathematics and for practice purposes if teachers do use them in schools.

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