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EFFECT OF THE USE OF GEOGEBRA ON JUNIOR HIGH SCHOOL STUDENTS' PERFORMANCE IN REFLECTION

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Abstract

The study sought to ascertain the effect of the use of GeoGebra on junior high school students' performance in reflection. The study employed quasi-experimental non-equivalent pretest-posttest design. One hundred and ten (110) JHS two (2) students from two school were assigned to control and experimental group. Data was collected using test in the form of pre-test and post-test. Data was analyzed using mean, standard deviation, independent sample t-test and Multivariate analysis of covariance (MANCOVA). The findings indicated that students' performance in the experimental group on post-test improved significantly as a result of the intervention (GeoGebra). Based on the findings, it was recommended among others that teachers incorporate GeoGebra in teaching and learning of reflection to facilitate better learning outcomes.

Keywords: GeoGebra, Rigid Motion, Reflection, Mathematics Performance

Introduction

The use of technology in the classrooms in today's world is believed to have a positive effect on students' success and their attitudes towards mathematics lessons (Ramadan & Hüseyin, 2014). As such, it is within the domain of mathematics teachers to create instructional techniques that will help students in learning mathematics. Leong (2013) asserts that the abundance of devices on the market is driving the amazing growth of technology use in pedagogy. Programmes and teaching methods that significantly affect both instruction and student achievement have been examined by policymakers and educators (Shieh, 2012). The employment of computer programmes has had a significant impact on the field of mathematics as well. There is evidence of the beneficial impacts of using interactive software on students' learning from research conducted in the 1990s and 2000s (Fried, 2008). These studies demonstrate how technology, namely the usage of interactive software like GeoGebra, enhances student learning and performance. According to Agyei and Benning (2015), using computer (interactive) software in the classroom has been beneficial to mathematics pedagogy. Mathematics is a very important subject across all levels of education in Ghana. At the Junior High School level, it is a subject that must be learned by all Junior High School pupils.

One aspect of geometry that enables mathematicians and learners of mathematics appreciate changes in the orientation of geometric shapes is transformation geometry. Geometric transformations that preserve lengths of segments and measures of angles are called rigid motions. Rigid motion of a plane is a motion which preserve distance. This consists of translation, rotation, and reflection. Rigid motions are hence transformations that result in congruent forms. According to research, pupils struggle to comprehend concepts and exhibit better performance in transformations (Agyei & Benning, 2015). Particularly when determining the coordinates of new pictures created by reflection, rotation, translation, and enlargement, students have failed to show that they possess the necessary knowledge and comprehension in this subject (WAEC Chief Examiners' report, 2017; 2018; 2019; 2020). These reports claim that candidates' weaknesses included their inability to locate and plot coordinates of a point, as well as their incapacity to solve issues using vectors. According to Asare (2019), about 95% of the students' experienced difficulties in geometry involving rigid motions. Zengin, Furkan, and Kutluca (2012) also criticized teachers' poor teaching abilities and a lack of resources for presenting geometrical forms to pupils for the lack of interest and comprehension of geometry among students. Supporting this claim, Asemani, Aseidu-Addo & Oppong (2017) highlighted the lack of resources to teach geometry, poor visualization abilities, poor reasoning, abstractness of the concept, and ineffective instruction as factors contributing to pupils poor performance in geometry The conventional approach in teaching geometry emphasizes more on how much the student can remember and less on how well the student can think or reason (Baffoe & Mereku, 2010). The basis of rigid motions and geometry in general is consequently quite poor for students who continue on to Junior High and Senior High School. Due to Ghana's predominant use of conventional techniques for teaching rigid motions, implementing a realistic teaching strategy, like the usage of GeoGebra, might be a potential solution for improving education and student learning, especially in light of students' difficulties in learning rigid motions.

Previous studies (Asare, 2019; Badu-Domfeh, 2020; Chimuka, 2017; Pinamang & Penrose, 2017) have demonstrated positive effects of GeoGebra instructional approach lessons on students’ performance in geometry. However, reading of the literature available indicate that many of these studies were not centered on GeoGebra instructional approach in teaching and learning rigid motions as a sub-topic under Geometry in Ghana and particularly, the Ho West District of the Volta Region of Ghana. Meanwhile, the Ho West District has a history of recording low mathematics performance in the Basic Education Certificate Examination (BECE). This indicates that there is a need for intervention strategies to improve students' understanding and performance in mathematics, specifically in the area of rigid motions. Perhaps, the integration of GeoGebra in teaching rigid motions will improve the performance of Junior High Schools students, particularly in the Ho West District of the Volta Region. In that regard, teaching reflection of plane figure, as aspect of rigid motions, particularly in the Junior High School, calls for more creative methods that will improve students' comprehension and geometry abilities. The use of technological tools, particularly the integration of GeoGebra software into the teaching and learning of geometry, is one of these cutting-edge approaches that is known to aid learners' understanding of geometry. In light of this, the study sought to find out the effect of GeoGebra integration on Junior High School students' performance in reflection of plane figures.

Purpose of the Study

The study sought to determine the effect of the use of GeoGebra on Junior High School students’ performance in reflection of plane figures.

Objectives of the Study

Specifically, the study sought to:

1. determine the effect of the use GeoGebra on the performance of students in reflection of plane figure.
2. find out the effect of the use of GeoGebra on the performance of students at Van Hieles’ visualization level of geometric thinking.
3. find out the effect of the use of GeoGebra on the performance of students at Van Hieles’ analysis level of geometric thinking.

Study Hypotheses

The following hypothesis were tested at 0.05 level of significance.

H_{01}: There is statistically no significant difference between the performance of students taught reflection of plane figures with GeoGebra and students taught with the conventional method

H_{02}: There is statistically no significant difference between the performance of students taught reflection of plane figure with GeoGebra and students taught with the conventional teaching method at the Van Hieles' visualization level of geometric thinking.

H_{03}: There is statistically no significant difference between the performance of students taught reflection of plane figure with GeoGebra and students taught with the conventional teaching method at the Van Hieles' analysis level of geometric thinking.

Theoretical Underpinnings

The study was anchored on Roger's Diffusion Innovation Model (2003) and Van Hieles' Theory of Geometric Thinking. The application of Rogers' Diffusion of Innovation theory and Van Hiele's (1957) Geometric Thinking to the study on the effect of GeoGebra on Junior High School students' performance in reflection of plane figures can provide valuable insights and frameworks for understanding the diffusion of technology and the cognitive development of geometric thinking among students. Rogers' Diffusion of Innovation theory can help explain the adoption and impact of GeoGebra, a technology tool, within the educational context. The theory suggests that the adoption of an innovation, such as GeoGebra, is influenced by factors such as the innovation's relative advantage, compatibility with existing practices, complexity, trialability, and observability. In this study, the theory can be applied to understand how and why students and teachers adopt GeoGebra for learning and teaching reflection of plane figures. It can also provide insights into the effectiveness of GeoGebra in improving students' performance in reflection of plane figures 1 and 2 as illustrated in figure 1 below.

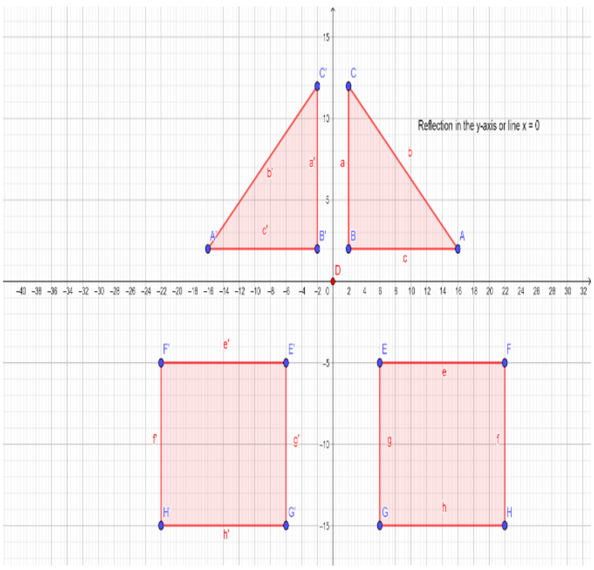

Figure 1: Reflection in the y-axis/ line x =0

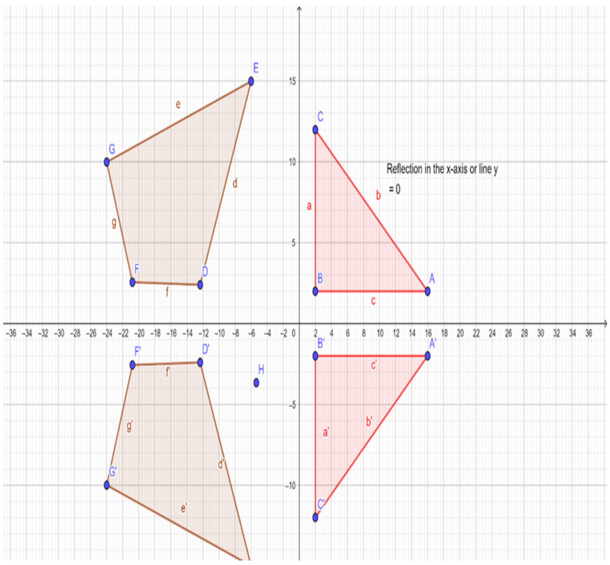

Figure 2: Reflection in the x-axis/ line y =0

Van Hiele's Geometric Thinking levels also provide a framework for examining students' cognitive development and understanding of geometry. The theory posits that students' progress through different levels of geometric thinking, from visual recognition to abstract reasoning. In this study, Van Hiele's levels can be used to assess and analyze students' performance in reflection of plane figures before and after the intervention with GeoGebra. It can help determine if the use of GeoGebra influences students' thinking and if there is a shift in their geometric understanding from lower levels (visualization) to higher levels (analysis). Applying Rogers' Diffusion of Innovation theory helped the researcher to ascertain the effect of the use of on students' performance in rigid motions, while Van Hiele's Geometric Thinking levels can provide insights into the cognitive development of students' geometric thinking. Together, these frameworks enriched the study by providing a theoretical lens to examine the process, effects, and underlying mechanisms of using GeoGebra in teaching and learning reflection of plane figures.

Methodology

The study was anchored in the positivist research philosophy, influenced by the quantitative approach, and was directed by quasi-experimental research design. The research design involved non-random assignment of respondent into two groups namely treatment (experimental) and control groups. The design is shown below:

Groups	Pretest	Treatment	Posttest
Experimental Group	O_1	X_1	O_2
Control Group	O_3	X_2	O_4

Figure 8: Quasi-Experiment (Non-equivalent group pretest-posttest design)

From the figure, O_1 = Pretest results of experimental group
O_2 = Posttest results of experimental group
O_3 = Pretest results of control group
O_4 = Posttest results of control group
X_1 = GeoGebra aided instruction (experimental group)
X_2 = Convention teaching method (control group)

Simple random sampling was used in selecting the two study sites and the respondents were assigned (non-randomization) into the two groups. In all a sample size of 110 respondents were used for the study. The study involved three stages: the administration of pre-test, intervention (or treatment stage), post-test. Analysis of data gathered from the pre-test and post-test was used to establish that the two groups were comparable. Thus, there was no statistically significant difference in mean score between the experimental and control group. Research question 1 was answered by comparing the mean scores of the experimental and control group under reflection of plane figure. The instrument was pre-tested to ensure reliability and validity. Hypotheses 1, 2 and 3 were t-tested for statistical significance using independent samples t-test. Also, ethical issues (anonymity, informed consent and confidentiality) governing the conduct of quantitative research were considered. Step were taken to treat treats to interval validity such as Sample Bias, Researchers Bias, Time, Change in Testing Procedure, Regression to Mean, Maturation, Testing and History.

Analysis of Demographic Data

Table 4. : Sex Distribution of Students

Sex	Control	Experiment	Total
Male	26	30	56
Female	28	26	54
Total	**54**	**56**	**110**

Source Fieldwork Data (2022)

The sex distribution of the students in both groups in Table 1 shows that the sample size for the study was 110 students comprising of 56 male and 54 female students. While the control group comprised of 56 students (30 males and 26 females), the experimental group comprised of 54 students (26 males and 28 females). This implies that there were more males in the experimental group than in the control group. Conversely, there were more females in the control group than in the experimental group. In all, there were more males than females in the sample for the study.

Table 2: Average age distribution of students

Group	Frequency	Percent	Mean
Control	54	49.1	13.32
Experimental	56	50.9	13.43
Total	**110**	**100.0**	

Source: Fieldwork Data (2022)

The data on Table 2 shows that the average age for the control group was 13.32 years (49.1%) while the average age for the experimental group was 13.43 years (50.9%). The age distribution for both groups implies that the students were of similar age group.

Results of Preliminary Test of Comparism

A pre-test was conducted for both groups to determine if students in both groups had equivalent competencies in reflection of plane figures before the introduction of the intervention (GeoGebra). The test was scored out of twenty (20) marks. The results of the pre-test are shown in Table 3.

Table 3: Results of independent samples T-test for pretest

Group	N	Mean	Std. Dev.	T	df	Sig-Value
Experimental	56	8.8	2.07	.032	108	.974
Control	54	8.7	2.01			

Source: Fieldwork Data (2022)

Results on Table 3 revealed that students in the experimental group had a mean mark (M = 8.8; SD = 2.07) than those in the control group (M = 8.7; SD = 2.01). This suggests that the mean score of the experimental group was slightly higher than the mean score of the control group. The standard deviation for the experimental group was 2.07, whereas the standard deviation for the control group was 2.01. The spread of marks from the mean mark of the control group was, as can be inferred from the standard deviation value, significantly higher than the spread of marks from the mean of the experimental group. From the Table 3, the sig (2-tailed) value is 0.974. This value is greater than the cut-off point of 0.05 ($P>0.05$). The p-value (sig = 0.974) provided evidence to suggest that there exists no statistically significance difference between the mean score (performance) of students in both the experimental and control group. The findings of the pre-test result implies that students in both groups had identical level of understanding of reflection of plane figures.

H_{01}: There is statistically no significant difference between the performance of students taught reflection of plane figures with GeoGebra and students taught with the conventional method.

Table 4: Independent samples t-test of students' performance in post-test

Group	N	Mean	Std. Dev.	T	Df	Sig-Value	Eta Squared
Experimental	56	13.2	1.7	0.074	108	0.000	0.33
Control	54	8.4	2.2				

Source: Fieldwork Data (2022)

As shown in Table 4.10, students in the experimental group had higher marks (M = 13.2; SD = 1.7) than those in the control group (M = 8.4; SD = 2.2). This suggests that the mean score of the experimental group was higher than the mean score of the control group. The standard deviation for the experimental group was 1.7, whereas the standard deviation for the control group was 2.2. The spread of marks from the mean mark of the control group was, as can be inferred from the standard deviation value, significantly bigger than the spread of marks from the mean of the experimental group. From the Table 4, the sig (2-tailed) value is 0.000. This value is less than the cut-off point of 0.05 ($P<0.05$). Therefore, there is statistically significance difference between the mean score (performance) of students in both the experimental and control group. Eta Squared Statistics 0.33 represents a large effect. Cohen, Manion and Morrison (2018) provide that an effect size of 0.01 represents small effect; 0.06 represents moderate effect and 0.14 represents large effect. It is, therefore, evident from the eta squared value evident that, 33% of the variance in the post test score is explained by groups. The findings of the post-test result implies that students in the experimental group performed much better that their counterparts in the control group. This suggests that incorporating GeoGebra into the teaching of reflection of plane figures in this study proved that a blended instruction with technology increases students' mathematical performance. The find collaborates with the assertion of Bhagat and Chang (2015) who discovered that students who were taught using GeoGebra as part of a blended instruction in mathematics performed better than those who were taught using the conventional method of instruction. Also, the results in in line with the findings of Eyyam and Yaratan (2014), who found that technology improves pupils' academic performance.

In experimental research, as in this study, the presence of extraneous variable (any variable not under investigating) can potentially affect the outcomes of research study. If extraneous variables are left uncontrolled, they can lead to inaccurate conclusions about the relationship between independent (use of GeoGebra in teaching and learning) and dependent variables (performance of students in reflection of plane figures). It is therefore important to determine the effect of these variables on the dependent variable through a statistical analysis. To determine the effect of the covariates on the performance of students in the experimental groups, Multivariate Analysis of Covariance (MANCOVA) was performed.

Table 5: Summary of MANCOVA of performance of students taught with GeoGebra

Source	Sum of Squares	Df	Mean Square	F	Sig.	
Pre-test	0.011	1	0.011	0.003	0.958	0.01
Age	2.420	1	2.420	0.602	0.439	0.02
Group	103.897	1	103.897	25.868	0.000	0.21
Error	425.741	106	4.016			
Corrected Total	534.591	109				

a. R Squared = 0.204 (Adjusted R Squared = 0.181)

The statistics from Table 5 indicate that there is a statistically significant main effect on the students who used GeoGebra to learn reflection of plane figures, [F (1, 106) = 25.868; p = 0.000 < 0.05]. Consequently, the students taught with GeoGebra method performed better than their counterpart who did not use GeoGebra to learn reflection of plane figures. The eta statistics squared value of 0.21 indicates a large effect size. Thus, 25.9% of the variance in the dependent variable (post-test scores) is expounded by the independent variable (GeoGebra). This implies that the magnitude of the difference between the mean score performance of the students taught with the GeoGebra method and the conventional method is large. With the high scores of students in the experimental group, it implies that the improvement in the performance of student was a result of the use of GeoGebra in the teaching and learning of reflection of plane figures. This means that when students are taught using GeoGebra as an instructional tool, their performance would improve drastically more than students taught using the conventional method in most Ghanaian classrooms.

H_{02}: There is statistically no significant difference between the performance of students taught reflection of plane figure with GeoGebra and students taught with the conventional teaching method at the Van Hieles' visualization level of geometric thinking.

Table 6: Results of Independent Samples T-Test for Posttest (Visualization level)

Group	N	Mean	Std. Dev.	T	df	Sig-Value	Eta Squared
Experimental	56	7.0	.89	3.276	108	.000	0.20
Control	54	5.6	.91				

Source: Fieldwork Data (2022).

Table 5 shows that at Van Hiele Visualization level there is a statistically significant difference in post-test marks of the experimental group (M = 7.0; SD = .89) and control group (M = 5.6; SD = .91); t (108) = 3.276; p = 0.000) in favor of the experimental group. Based on these results, the null hypothesis was rejected. This implies that, the difference in the posttest scores of the experimental and control group did not occur by chance. Therefore, the integration of GeoGebra into the teaching and learning of rigid motion help to improve student's performance. Based on this finding, the null hypothesis was accordingly rejected. This confirms the findings of Chimuka (2017) that the use of GeoGebra improves students' achievement, improves students' geometric thinking at some Van Hieles' visualization level and motivates students to learn geometry. The Eta Squared Statistics 0.20 represents a large effect. Cohen, Manion and Morrison (2018) provide that an effect size of 0.01 represents small effect; 0.06 represents moderate effect and 0.14 represents large effect. It is, therefore, evident from the eta squared value evident that, 20% of the variance in the post test score is explained by the treatment group.

H_{03}: There is statistically no significant difference between the performance of students taught reflection of plane figure with GeoGebra and students taught with the conventional teaching method at the Van Hieles' analysis level of geometric thinking.

Table 6: Independent samples Test of students' performance in analysis (Level 1)

Group	N	Mean	Std. Dev.	T	Df	Sig-Value	Eta Squared
Experimental	56	6.2	0.66				
				3.996	108	.000	0.13
Control	54	2.6	0.76				

Source: Fieldwork Data (2022)

Table 6 shows that there is a statistically significant difference in average post-test marks of the experimental group (M = 6.2; SD = 0.66) and control group (M = 2.6; SD = 0.76; t (108) = 3.996; p = 0.000) in favor of the experimental group. Based on this finding (p=0.000), the researcher rejected the null hypothesis. This implies that, the difference in the posttest scores of the experimental and control group was significant. Therefore, the integration of GeoGebra into the teaching and learning of rigid motion help to improve student's performance in analysis level of Van Hieles' geometric thinking. Based on this finding, the null hypothesis was accordingly rejected. The findings of the study confirm the assertion of Muriki (2016) who opines that GeoGebra software enables students to investigate various form characteristics, which enhances their relational grasp of geometric concepts. The findings support the view that students' digital exposition improves while using GeoGebra, and this is closely linked with cognitive performance as a result, learning both geometrical and mathematical concepts become simpler for students (Di Giacomo, Ranieri & Lacasa, 2017). To determine the effect size of the use of GeoGebra in teaching rigid motion, the researcher computed the effect size statistics (i.e the strength of association between the means). The Eta Squared Statistics was 0.13. The eta squared value of 0.13 represents a moderate effect. According to Cohen, Manion and Morrison (2018) provides that an effect size of 0.01 represents small effect; 0.06 represents moderate effect and 0.14 represents large effect. It is, therefore, evident from the eta squared value evident that, 13% of the variance in the post test score is explained by group. This means that the use of GeoGebra had a moderate effect on the performance of students in reflection of plane figures.

Study Findings

The key findings are presented in this section. The study revealed three (3) key findings. The key findings are discussed as follows:

1. The findings indicate that incorporating GeoGebra in teaching reflection of plane figures leads to a statistically significant improvement in students' performance compared to conventional teaching methods. This suggests that the use of GeoGebra as an instructional tool can enhance students' understanding and application of reflection concepts. Teachers and educators can consider integrating GeoGebra into their geometry instruction to facilitate better learning outcomes.
2. The findings show that students taught reflection of plane figures with GeoGebra perform significantly better at the Van Hiele's visualization level of geometric thinking compared to students taught with conventional methods. This implies that GeoGebra's

interactive features and visual representations support students' ability to visualize and comprehend geometric concepts. Educators can leverage GeoGebra to foster students' visualization skills, helping them develop a solid foundation in geometric thinking.

3. The findings also reveal that students taught reflection of plane figures with GeoGebra perform significantly better at the Van Hiele's analysis level of geometric thinking compared to students taught using conventional methods. This suggests that GeoGebra's dynamic capabilities and tools aid students in analysing and manipulating geometric figures, leading to deeper understanding and problem-solving skills. Educators can utilize GeoGebra to facilitate students' analytical thinking in geometry, promoting higher-order cognitive processes.

Conclusions and Recommendations

The study highlighted the positive impact of integrating GeoGebra in teaching reflection of plane figures. The use of GeoGebra not only improves students' performance but also enhances their visualization skills and analytical thinking in geometry. These implications support the adoption and implementation of GeoGebra as an effective technology tool in geometry instruction, potentially benefiting students' learning experiences and outcomes.

From the findings of this study, the following recommendations are made for Mathematics teachers and other stakeholders. The recommendations are presented according to the findings of the study.

1. Teachers and educators are encouraged to integrate GeoGebra, a dynamic geometry software, into their instruction of reflection of plane figures. The findings indicate that the use of GeoGebra significantly improves students' performance compared to conventional teaching methods. Incorporating GeoGebra's interactive features and visual representations will help teachers enhance students' understanding and application of reflection concepts.
2. The study demonstrates that students taught with GeoGebra perform significantly better at the Van Hiele's visualization level of geometric thinking. Therefore, educators should prioritize the development of visualization skills in geometry instruction. Using GeoGebra and other visual representations would help teachers to provide ample opportunities for students to visualize and manipulate geometric figures, fostering a strong foundation in geometric thinking.
3. The findings indicate that students taught with GeoGebra perform significantly better at the Van Hiele's analysis level of geometric thinking. To promote analytical thinking in geometry, educators should design tasks and activities that encourage students to explore and analyse geometric properties, relationships, and transformations using GeoGebra. Providing opportunities for students to engage in problem-solving and critical thinking will enhance their analytical skills.

Suggestions for further studies

While the findings of this study support the effectiveness of GeoGebra in promoting students' performance and geometric thinking, further research is recommended. Future studies can explore the long-term effects of integrating GeoGebra in geometry instruction and investigate its impact on other aspects of geometric thinking, such as spatial reasoning and problem-solving abilities. These recommendations aim to enhance geometry instruction and improve students' learning outcomes by leveraging the benefits of GeoGebra. Through the incorporation of technology tools and emphasizing visualization and analytical thinking, educators can create engaging and effective learning experiences in reflection of plane figures.

References

Agyei, D. D., & Benning, I. (2015). Pre-service teachers' use and perceptions of GeoGebra software as an instructional tool in teaching mathematics. *Journal of Educational Development and Practice, 5(1)*, 14- 30.

Asare, T. J. (2019). *Impact of using Geogebra software in teaching and learning rigid Motion on Senior High School Students in Ghana* (Unpublished Master of Philosophy Thesis). Department of Mathematic Education, University of Education, Winneba.

Badu-Domfeh, A. K. (2020). Incorporating Geogebra software in the teaching of circle theorem and its effect on the performance of students. UCC: Sam Jonah Liabrary.

Baffoe, E., & Mereku, D.K. (2010). *The Van Hiele levels of understanding of students entering senior high school in Ghana. African Journal of Educational Studies in Mathematics and Sciences. 8. 10.4314/ajesms.v8i1.69103.*

Chimuka, A. (2017). *The effect of integration of geogebra software in the teaching of circle geometry on grade 11 students' achievement* (Doctoral dissertation). University of South Africa, Pretoria, South Africa.

Cohen, L., Manion, L., & Morrison, K. (2018). Research Methods in Education (8th ed.). London: Routledge.

Di Giacomo, D., Ranieri, J., & Lacasa, P. (2017). Digital learning as enhanced learning processing? Cognitive evidence for new insight of smart learning. *Frontiers in psychology*, *8*, 1329.

Eyyam, R., & Yaratan, H. S. (2014). Impact of use of technology in mathematics lessons on student achievement and attitudes. Social Behavior and Personality: *An international journal, 42(0), S31-S42.*

Fried, C. B. (2008). In-class laptop use and its effects on student learning. *Computers & Education, 50(3)*, 906-914.

Leong, K. E. (2013). Impact of Geometer's Sketchpad on student's achievement in graph functions. *The Malaysian Online Journal of Educational Technology*, 1(2), 19-31.

Mukiri, M. I. (2016). *Feasibility of Using Geogebra in the Teaching and Learning of Geometry Concepts in Secondary Schools in Kajiado County, Kenya* (Doctoral dissertation) Kenyatta University, Nairobi, Kenya.

Pinamang, I. & Penrose O. C. (2017). Pre-service teachers' content knowledge and pedagogical content knowledge in teaching geometric transformation. *African Journal of Educational Studies in Mathematics and Sciences*, 13 (4), 12-21

Rogers, E. M. (2010). *Diffusion of innovations*. Simon and Schuster. Routledge

Shieh, R. S. (2012). The Impact of Technology-Enabled Active Learning (TEAL) implementation on student learning and teachers' teaching in a high school context. *Computers & Education*, *59*(2), 206-214.

Van Hiele-Geldof, D. (1957). The problem of insight, in connection with school children's insight into the subject matter of geometry. Utrecht: University of Utrecht.

West African Examination Council (2017). West African senior secondary school certificate examination May/June Chief examiner's report. WAEC: Accra.

West African Examination Council (2018). West African senior secondary school certificate examination May/June Chief examiner's report. WAEC: Accra.

West African Examination Council (2019). West African senior secondary school certificate examination May/June Chief examiner's report. WAEC: Accra.

West African Examination Council (2020). *West African senior secondary school certificate examination May/June Chief examiner's report*. WAEC: Accra.

Zengin, Y., Furkan, H., & Kutluca, T. (2012). The effect of dynamic mathematics software geogebra on student achievement in teaching of trigonometry. *Procedia-Social and Behavioral Sciences*, *31*, 183-187.