EFFECTS OF PROBLEM SOLVING INSTRUCTIONAL STRATEGY ON STUDENTS' ACADEMIC ACHIEVEMENT IN GEOMETRY IN GWALE LOCAL GOVERNMENT AREA SECONDARY SCHOOLS, KANO, NIGERIA

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Abstract
This study investigated the effects of problem solving strategy on students' academic achievement in geometry. The study adopted pre-test, post-test quasi experimental design and control group design. The population of the study was twenty one thousand, seven hundred and nine (21709) senior secondary school (SS II) students in Gwale L.G. While the sample for the study consist of two hundred and eleven (201) students which comprise one hundred and five (105) male and ninety six (96) female students. Stratified random sampling technique was used in the study based on gender. The instruments used in the study were Geometric Achievement Test (GAT) and Geometric Attitude Questionnaire (GAQ), where GAT was adapted by the researcher from New General Mathematics Book and WAEC past question paper. GAT was validated by experts: two from Mathematics Unit, KERD and three from Mathematics department BUK ranking from senior lecturer. Pilot study was conducted and used split-half reliability method, and the GAT and GAQ reliability index were computed to found 0.95 and 0.89 respectively using Spearman Rank Order Coefficient. Four research questions and four research hypotheses were formulated to guide the study. The research questions were answered using Mean and Standard Deviation. While the hypotheses were tested at 0.05 level of significance and analyzed using Wilcoxon rank and z-test. The result showed that; there was significant difference in the students' academic achievement when taught geometry using problem solving instructional strategy. The findings also indicated that problem solving strategy affect both male and female students' attitude toward geometry. Finally, the study recommend that mathematics teachers should incorporate problem solving strategy in teaching and learning geometry as it improve students' academic achievement and attitude.

Keywords: *Mathematics, Geometry, Problem-solving, Academic Achievement*

Introduction

Mathematics is an essential tool needed for the successful development of any nation. According to Timayi, Ibrahim & Sirajo (2016) Mathematics is a logical language for expressing ideas, shapes, quantities, size, order, change and dynamism of single and complex system. Nkwocha (2016) define mathematics as a science of numbers and systematic reasoning for solving problem. The researcher further explain that, mathematics is a science of numbers and shapes which include Arithmetic, Algebra, Geometry, Statistics and Calculus. Mathematics was viewed as the science of quantity, where science was classified into discrete i.e. the study of Arithmetic

and continuous i.e. the study of geometry (Aristotle in Yadav, 2017). It is the relationships that revolve around the practice of counting, measurement and describing shapes and spaces (Soyem, 2001 in Anaduaka, 2008). The importance of mathematics in the development of human being cannot be estimated, this might be the reason why mathematics is made compulsory subject in Nigeria Education Curriculum at both primary and secondary school level of education (National Policy on Education, 2014; Fasasi, 2015).

These definitions of mathematics clearly indicate that geometry is an integrated part of mathematics, in fact it is a basic mathematical skill. Cooper (2011) opined that geometry is a gateway to mathematics and geometry could be applied as an approach to numerous topics throughout all branches of mathematics. It is an important branch of mathematics that deals with study of points, lines, shapes, spaces, sizes and position of two and three dimensional figures (Feldman, 2011; Kurumeh, Samuel, Odoh & Ikyereve, 2016).

The importance of geometry to human life cannot be overemphasized because the world we are living in today is surrounded by different shapes and occupied spaces. Geometry help us to understand a spatial relationship, it creates a clear perception of space and position through studying the size and shapes of everything in the world. Geometry helps to understand the measurement and relationships of points, lines, angles, surface and solids shapes found in everyday world (Jones, 2002). The emphasis of geometry is increased as students' progress from primary to secondary education. Unfortunately despite the importance of geometry and its relation to human development, the achievement of students in this aspect is poor (Adolphus, 2011; Ali, Bhagawati & Sarmah, 2014; WAEC Chief Examiners' Report 2013; 2014; 2015).

At all educational level in Nigeria, mathematics teachers cannot say it is well with teaching and learning geometry. Many teachers find it difficult to teach geometry effectively in classroom, this is why students always fail geometric questions neither in internal exam nor external exam. Geometry become a challenged topic to teach in mathematics, an evidence from WAEC Chief Examiner's report (2013; 2014; 2015), indicate that students skip or fail to answer geometric questions in their examination. The examiner concluded that, the students' failure has a direct link with the method of teaching used by mathematics teachers in classroom. Geometry is an important topic in mathematics where problem of teaching and learning occurs most, students misunderstand the concepts of geometry in general (Sambo, 2015). All this difficulty of teaching or learning of geometry directly or indirectly is associated with the method of teaching used by mathematics teachers as mentioned in the WAEC Chiefs examiners' report.

Mathematics teachers are utilizing the traditional strategy of teaching and learning in geometric classroom (Garbett, 2011; Fatade, Mogari & Arigbabu, 2013; Nwoke, 2015). Traditional strategy of teaching is popularly known as conventional method of teaching, which required the use of chalkboard and textbook. This method of teaching does not respect students' knowledge and experience. This strategy of teaching practiced in mathematics classroom and geometry in particular, is yet to produce a significant result rather than promoting rote learning for many years back, where students memorized facts, formulae, rules and procedure. The method prevents students' social development and academic achievements in mathematics at large (Aydisheh & Gharibi, 2015). One way to address this situation may be to give trial to problem-solving strategy that is, teaching of geometry through problem-solving strategy (Donaldson 2011; Kirtikar, 2013 & Kurumeh et al 2016).

Attitude is another factor that affect students' academic achievement in geometry apart from the traditional method of teaching (WAEC Chief Examiners' Report 2013; 2015; Ameen, Salman & Adeolowo, 2017). Attitude play a vital role in students' academic achievement in

mathematics and geometry in particular. Odogwu & Mbah (2015) defined attitude as a set of positive or negative pre-acquired emotion, opinions, and behavior toward an object, a fact, or a concept. Students' attitude toward mathematics is defined as the positive or negative emotional response of students toward mathematics, willingness to succeed in learning mathematics and strategies in solving mathematical problems (Iji & Obarakpo, 2017). Many research shown that students attitude toward learning geometry has influence in their academic achievement in mathematics (Zan & Martino, 2007; Ajisuksmo & Saputri, 2017). It was believed that problem solving enhanced students' attitude toward mathematics and geometry as concluded by Kurumeh et al 2016).

A problem-solving is a process of learning through the natural thinking that occurs when someone faces a problem (Donaldson, 2011; Eduafo, 2014). The problem-solving strategy is an attempt to make teaching and learning geometric concept an active and real rather than abstract as in the case of conventional strategy. Problem-solving strategy is a student centered method of teaching, it require students active participation. Many researchers such as (Gok & Silay 2010; Dannawi 2013; Eduafo 2014) believed that problem-solving strategy improve students' achievement in geometry and mathematics in general, and it fills the gap that exist between male and female students' academic achievement in mathematics.

Problem solving strategies or models were used for teaching and learning mathematics in order to attain a desired academic achievement of learners (Iji & Obarakpo, 2017; Olaoye & Iroko, 2018). There are so many problem solving models developed by different authors and researchers for teaching and learning more especially Sciences, Technology, and Mathematics Education (STME) courses among are, Polya Model, IDEAL Model by Branford & Stain, Rusbult Model etc. (Karatas, Soyak & Alp, 2015; Kurumeh et al, 2016; Phillips, McCallum, Clemmer and Zachariah, 2016).

In this study ACE-M problem solving model was adopted in the treatment of the experimental group. ACE-M model is chosen base on the reason that the model is newly proposed in fact the model is new in Nigeria context. ACE-M model was developed for the purpose of teaching and learning Mathematics and other Sciences courses (Phillips *et al* 2016). Monitoring was emphasized in this model, where each component of the model has to be monitored, this make the model different from many other models. ACE-M model has four component; Analyze the problem, Create a plan, Execute the plan, and Monitor understanding and Action. Ideally the model has three component because monitoring is not a separate component, rather an integrated part of each component of the model (Phillips *et al* 2016). They further opined that the model will assist teachers and students when teaching and learning, and is effective in improving students' academic achievement and attitude toward learning mathematics and sciences. Fig. 1 shows the pictorial design and brief explanation of the component of the model.

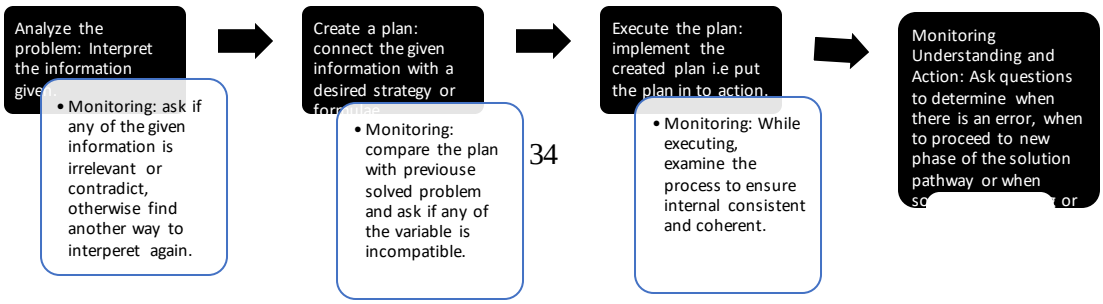

Figure 1: ACE-M Problem Solving Model Developed by Phillips, McCallum, Clemmer and Zachariah, 2016

Perveen (2010) carryout a research titled "Effect of Problem Solving Approach on Academic Achievement of Students' in Mathematics of Secondary Level" with forty female students' in 10th grade of the Government Pakistan Girls High School Rawalpindi as the sample of the study. Quasi-experimental research design was adopted for the study. The research revealed that the students' academic achievement in mathematics was improved when tough using problem solving instructional strategy compared to the expository strategy. Ifamuyiwa & Ajilogba (2012) conduct a research on problem solving model as a strategy for improving secondary school students' achievement and retention in further mathematics. Ifamuyiwa and Ajilogba check the empirical evidence on the effect of Oyedeji Problem Solving model as a strategy (OPSS) on secondary school students' achievement and retention in further mathematics, with a sample of 80 students' made up of 40 male and 40 female students offering further mathematics were choose from the population of senior secondary school class two (SS II) in Ogun State. Experimental research design was employed for the study. The researchers conclude that the model affect achievement and retention of students' in further mathematics. It also revealed that there is no significant different in the achievement and retention of male and female students in further mathematics. Nwoke (2015) explored a research on the "Impact of problem solving approach on senior secondary school students' achievement in mathematics". The study adopted Quasi-experiment design , with sample of one hundred and fifty five (155) students' consist 74 male and 81 female students selected using purposive sampling technique from the population of all senior secondary school one in Owerri North Local Government of Imo State. The researcher conclude that, problem-solving strategy improve students' academic achievement in mathematics and it show no gender bias. Iji & Obarakpo (2017) published an article Title "through the utilization of Rusbult problem solving model in Keffi Metropolis, Nassarawa state Nigeria, enhancing senior secondary school students' achievement and interest in geometry". Multi-stage sampling technique was used for the selection of 84 sample students, made up 45 males and 39 females. The researchers concluded that, teaching geometry through Rusbult problem solving model improved academic achievement and interest of students, it also found that the model was gender friendly.

Statement of the Problem

Despite the importance of mathematics (Geometry in particular) and its role in the development of human life, it is very unfortunate that students' academic Achievement in the subject is disappointing. Students' underachievement in mathematics has become a continual problem in Nigeria. Mathematics is the only subject widely disliked and abysmally understood by Nigerian students (Fasasi, 2015; Utibe, 2015), not only in primary or secondary school, even in tertiary institution including universities in Nigeria, students are not studying the subject by their choice in most cases. The annual report release every year by WAEC chief examiner confirmed the

students' poor achievement in mathematics, for instance the percentage of pass for 2013, 2014, 2015, 2016 and 2017 are respectively 36.0, 31.30, 34.18, 38.68 and 59.22. It is only in 2017 the student achievement was significant. The report also shows that students avoid or fail to answer geometric questions in mathematics examination, where the failure was linked to poor method of teaching used by mathematics teachers.

A long period of time, traditional method of teaching and learning were practiced in many classrooms in Kano and Nigeria at large (Anaduaka, 2008; Ekirigwe, 2010; Adama, 2014). Traditional method of teaching is more of teacher centered, where teachers dominate the class activities and it doesn't consider students' status and experience. This method of teaching made teaching and learning geometry in an abstract world, rather than real life situation, where the method emphasize on how much the students can remember and less on how students can think, create, reason and apply the learned skills (Ali, 2013; Festus, 2014). This shows that the strategy is not contributing toward achieving the objectives of teaching and learning geometry rather than promoting rote learning (Ekirigwe, 2010), it also attributes in the students' negative attitude toward geometry.

It is clear that traditional method of teaching affect academic achievement and attitude of students in geometry. Several research on how to improve academic achievement of the students in geometry has been made using Poly's and Rusbult problem solving model. This study search for alternative way of improving the students' academic achievement and attitude toward geometry using ACE-M problem solving model.

Objectives of the Study

This research work was designed to attain the fallowing specific objectives, i.e. to:

1. Find out the effects of problem-solving strategy on SS II students' academic achievement in geometry.
2. Investigate the effects of problem solving strategy on SS II students' attitude toward geometry.
3. Determine the differential effects of problem solving strategy on SS II male and female students' academic achievement in geometry.
4. Examine the effects of problem solving strategy on SS II male and female students' attitude toward geometry.

Research Questions

This research work was designed to answer the fallowing question;

1. What is the effects of problem-solving strategy on students' academic achievement in geometry?
2. Does problem-solving strategy influence students' attitude toward learning geometry?
3. What is the differential effects of problem-solving strategy on male and female students' academic achievement in geometry?
4. What is the attitude of male and female students' toward geometry when taught using problem solving strategy?

Research Hypothesis

Based on the research questions highlighted, the following null hypotheses were developed and tested at 0.05 level of significance.

H_{o1}: There is no significant difference in the academic achievement of students' taught geometry using problem-solving strategy and those taught using traditional strategy.
H_{o2}: There is no significant difference in the attitude of students before and after teaching geometry using problem-solving strategy.
H_{03}: There is no significant difference in the academic achievement of male and female students taught geometry through problem-solving strategy.
H_{04}: There is no significant difference in the attitude of male and female students' toward geometry when taught through problem solving.

Methodology

The research design for the study was quasi-experimental design, having experimental and control groups, adopting the method of pre-test and post-test design. This design was used to describe the effect of problem-solving strategy on students' achievement in geometry in comparison with the traditional instruction (Lecture method).

The population of the study comprised of twenty one thousand, seven hundred and nine (21709) SS II students found in Gwale local government area, Kano State. The second year students have one more year to complete their program and therefore, they have time to adjust to any change in strategy. Moreover, the final year students (that is SS III), have a lot of pressure on them, they were engaged and busy to round off. But the first year students (that is SS I) they may view this strategy as a normal strategy of teaching geometry in senior secondary schools and they may feel unwilling to learn geometry through this strategy.
Stratified sample technique was used, where four schools were selected for the study. Intact classes were randomly selected for the study from the selected schools. Two schools were through balloting assigned to be experimental and other two to be control groups (Boys and Girls in each group). This make the sample size to be two hundred and one (201) students comprising one hundred and five (105) male students and ninety sixty (96) female students.

Data Collection Instruments

Two instruments were used in this study to collect relevant information. These are Geometric Achievement Test (GAT) and Geometric Attitude Questionnaire (GAQ). The Geometric Achievement Test (GAT) was adapted by the researcher from the book New General Mathematics by Macrae *et al* (2014) and WAEC past questions papers. Both GAT and GAQ were validated by experts, the GAT was validated by Two chief education officers Mathematics Unit, KERD and Three mathematics lecturers Mathematics Department, BUK, while the GAQ was validated by lecturers from the Department of Science Education BUK. The reliability coefficient of GAT and GAQ are respectively 0.95 and 0.89, using Spearman rank order correlation coefficient. The reliability coefficient was found by adopting Split-half reliability method. Immediately after the pretest treatment emerged which lasted for the period of eight weeks.

Data Analysis Procedure

The collected data was analyzed by the use of Mean, Standard Deviation, Wilcoxon rank and Z-test statistics. All the research questions were analyzed using Mean and Standard Deviation, while Wilcoxon-test and z-test were used in testing the null hypotheses at 0.05 level of significance.

Presentation of Results

The research questions and the corresponding hypotheses were answered and tested using one table. These are presented as follows:

Research Question one
What is the effect of problem-solving strategy on students' academic achievement in geometry?

Null hypothesis one
There is no significant difference in the academic achievement of students' taught geometry using problem-solving strategy and those taught using conventional strategy.

Table 1: Mean, Standard Deviation and Independent Z-test on students' Achievementin Geometry between Experimental and Control groups

		Posttest					
Groups	N	$\bar{x}$	SD	df	Z	P-value	Remark
Experimental	106	17.69	4.52				
				199	2.10	0.037	Reject H_{o1}
Control	95	14.23	3.12				

Table 1 shows that the experimental group had a mean achievement score of 17.62 while the control group scored 14.23 In addition, their respective standard deviation (SD) are 4.52 and 3.12. Clearly, the experimental group outperformed the control group with a mean difference of 3.46. This shows that problem solving is more effective compared to the traditional method of teaching. The result also revealed that the Z-value of 2.10 and P-value of 0.037 were observed at 199 degree of freedom. Since the P-value of 0.037 is less than the alpha value of 0.05, this means that there is significant difference between the experimental groups and the control group in terms of their mean performance. Therefore, the null hypothesis (H_{o1}) is hereby rejected. It is concluded that the experimental group performed better than the control group.

Research Question Two:
Does problem-solving strategy influence students' attitude toward learning geometry?

Null Hypothesis Two
H_{o2}. There is no significant difference in the attitude of students before and after teaching geometry using problem-solving strategy.

Table 2: Shows Mean, Standard Deviation and Wilcoxon Rank Test for the Students' Attitude toward Geometry

Students Attitude	N	$\bar{x}$	SD	Mean Diff.	Z-value	P	Remark
Before Treatment	106	57.42	15.92				
				13.09	-5.81	0.000	Reject H_{o2}

After Treatment	106	70.51	12.76

Table 2 shows that students' attitude before treatment had a mean of 57.42 with a standard deviation of 15.92 while the mean of the attitude of the students after treatment was 70.51 with a standard deviation of 12.76. This clearly indicate that, the mean of the student attitude after treatment is higher than the mean of the students' attitude before the treatment with mean difference of 13.09. This shows that problem solving enhance the students attitude toward learning geometry. On the other hand, testing the hypothesis revealed that the Z-value of -5.81 and P-value of 0.000 were observed. Since the P-value of 0.000 is less than the alpha value of 0.05, this means that there is significant difference between the students' attitude before treatment and after the treatment in terms of their mean. Therefore, the null hypothesis (H_{o2}) is hereby rejected. It is concluded that, problem solving strategy improve on the students attitude toward learning geometry.

Research Question Three:
What is the differential effect of problem-solving strategy on male and female academic achievement in geometry?

Null Hypothesis Three:
H_{03}: There is no significant difference in the academic achievement of male and female students taught geometry through problem-solving strategy.

Table 3: Mean, Standard Deviation and Independent Z-test on Male and Female students' Achievement in Geometry

				Posttest			
Gender	N	$\bar{x}$	SD	Df	Z	P-value	Remark
Male	55	15.56	4.26				
				104	-2.74	0.007	Reject H_{o3}
Female	51	17.90	4.51				

Table 3 shows that male students had a mean score of 15.56 with a standard deviation of 4.26 while the female students had a mean score of 17.90 with a standard deviation of 4.51. This clearly indicate that, the female students outperformed their male counterpart with mean difference of 2.34. This shows that problem solving strategy affect female students' more. On the other hand, testing the hypothesis revealed that the Z-value of -2.74 and P-value of 0.007 were observed. Since the P-value of 0.007 is less than the alpha value of 0.05, this means that there is significant difference between male and female students' in terms of their mean. Therefore, the null hypothesis (H_{o3}) is hereby rejected. It is concluded that female students performed better than their male counterpart.

Research Question Four:
What is the attitude of male and female students' toward geometry when taught using problem solving strategy?

Null Hypothesis Four

H_{04}: There is no significant difference in the attitude of male and female students' taught through problem solving.

Table 4: Shows Mean, Standard Deviation and Wilcoxon Rank Test for the Male and Female Students' Attitude toward Geometry

		Students Attitude after Treatment					
Gender	N	$\bar{x}$	SD	Z	P	Mean Diff	Remark
Male	55	70.44	14.64	-3.40	0.001	0.15	Reject H_{04}
Female	51	70.59	10.50	-2.24	0.000		

Table 4, shows that male students attitude had a mean of 70.44 with a standard deviation of 14.64 while the female students attitude had a mean of 70.59 with a standard deviation of 10.50. This shows that, the mean of the female students' attitude is higher than that of male with mean difference of 0.15, even though the mean difference is very small in fact it is insignificant. This shows that problem solving strategy affect both male and female students' attitude toward geometry. However, the hypothesis revealed that the male attitude had Z-value of -3.40 with P-value of 0.001 and female attitude had Z-value of -2.24 with P-value of 0.000 were observed. In both cases the P-value is less than the alpha value 0.05, this means that there is significant difference in the male and female students' attitude after treatment in terms of their mean. Therefore, the null hypothesis (H_{o4}) is hereby rejected. It is concluded that problem solving strategy enhanced both male and female students' attitude toward geometry.

Discussion of Findings

The finding in Table 1 showed that students taught geometry through problem solving instructional strategy recorded a posttest mean 17.69 with a standard deviation 4.52 while the posttest mean for students taught through traditional strategy was 14.23 with standard deviation 3.12. This shows that problem-solving instructional strategy improve students' academic achievement better than traditional strategy. It was found that the difference in mean achievement for post-test was significant at 0.05 alpha value as the Z-value 2.10 with P-value 0.037, since the P-value is less than alpha value then the null hypotheses (H_{01}) is rejected. This clearly indicate that problem solving strategy affect students' academic achievement. These findings is similar to the finding of Perveen (2010), Ifamuyiwa & Ajilogba (2012) and Iji & Obarakpo (2017).

The result in Table 2 showed that the attitude of students toward geometry before applying problem solving instructional strategy had a mean 57.42 with standard deviation 15.92, while the mean of the students' attitude after they were exposed to problem solving strategy was 70.51 with standard deviation 12.76. This shows that problem-solving instructional strategy has influence in the students' attitude toward geometry. Testing the hypothesis indicate that the students' attitude toward geometry was significant at 0.05 alpha value having Z-value -5.806 with associated P-value 0.000, since the P-value is less than 0.05 then the hypothesis stated "there is no significant difference in the attitude of students before and after teaching geometry using problem-solving strategy" is hereby rejected. This finding is in line with the research carried out by Nwoke (2015) and Iji & Obarakpo (2017).

The finding in Table 3 showed that male and female students' taught geometry through problem solving instructional strategy recorded posttest mean 15.56 and 17.90 with standard deviation 4.26 and 4.51 respectively. It is clear that, there is significant difference between male and female when taught using problem-solving strategy. The hypothesis affirmed that the difference in the students achievement for posttest was significant at 0.05 alpha-value having Z-value -2.74 with P-value 0.007, since the P-value was less than alpha-value. Clearly, the female students outperform their male counterpart by having high mean score in the posttest. This finding contradict the conclusion of; Nwoke (2015), Iji & Obarakpo (2017) whose finding shows problem solving strategy bridge the gap between male and female students academic achievement.

Table 4 shows that the mean of the male and female students' attitude after treatment respectively are 70.44 and 70.59. This shows that problem-solving strategy has influence on both male and female students' attitude toward learning geometry, however there is small difference of 0.15 which is insignificance. Following the analysis of the hypothesis, it was found that male and the female students' attitude toward learning geometry was significant at 0.05 alpha-value by having Z-value of -3.402 and -5.021 with P-value of 0.001 and 0.000 respectively. it is clear that the hypothesis stated "There is no significant difference in the attitude of male and female students' taught through problem solving" is hereby rejected. Then problem solving strategy affect both male and female students' attitude toward geometry.

Conclusions

The study conclude that; Problem solving instructional strategy improve students' achievement in geometry. The strategy has effects on the students' attitude toward geometry. Also it shows that the strategy has more effect on female students, this means that problem solving has gender bias even though the bias can be emerged from the model used in the study. It also revealed that the strategy influence both Male and female students' attitude toward geometry.

Recommendations

The following recommendation were made in accordance with the finding of the study:

1. The study recommend that mathematics teachers should incorporate problem solving strategy in teaching geometry as it improve academic achievement of students, this will reduce students' failure.
2. Education stakeholders should encourage the use of problem solving strategy through organizing seminars and workshops to acquaint mathematics teachers with how to use problem solving strategy in geometric classroom
3. Government, NGO's and mathematics educators should emphasize on the use of problem solving strategy as its minimized the gender imbalance in academic achievement as well as influencing students' attitude toward learning geometry across all genders.
4. The study also, recommends that researchers should carry out more research on ACE-M problem solving model to determine its effect on other aspect in mathematics.

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