EFFECT OF ELABORATION STRATEGY ON METACOGNITION OF SENIOR SECONDARY TWO STUDENTS IN GEOMETRY IN LANGTANG NORTH, PLATEAU STATE, NIGERIA

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Abstract
The study investigated the effect of Elaboration Strategy on Metacognition of Senior Secondary Two Students in Geometry in Langtang North, Plateau State, Nigeria. The quasi-experimental design of the non-equivalent control group design was adopted for the study. The population of the study was 1362 Senior Secondary Two (SS2) students comprising 730 males and 632 females in SS2. A sample of 175 (90 males and 85 females) SS2 students (represented 13% of the population) participated in the study using three-stage cluster sampling technique. Two research questions were raised and answered. Three hypotheses were tested at 0.05 level of significance. Data were collected using Metacognition Scale in Geometry (MSG). The MSG was an adapted questionnaire from Zepeda (2015). Items of MSG were scrutinised by three experts from the University of Jos, each in Psychology, Measurement and Evaluation, and Mathematics. The reliability of MSG was calculated using Cronbach's Alpha, and a high internal reliability of 0.91 was obtained. To ensure stability, a test re-test analysis using Pearson Product Moment Correlation was done and it yielded 0.72. The experimental group was taught using the Elaboration Strategy Lesson Plan (ESLP) while the control group was taught using the Conventional Strategy Lesson Plan (CSLP) by the trained research assistants. The treatment lasted for four weeks. The data collected were analysed using mean, standard deviation, and Analysis of Covariance (ANCOVA) in Statistical Packages for Social Sciences (SPSS) version 20. Findings of the study showed that SS2 students' metacognition in geometry in the experimental group was significantly higher than that of their counterparts in the control group. There was no significant difference between SS2 male and female students' metacognition in geometry in the experimental group. It was recommended that Mathematics teachers should use elaboration strategy to enhance senior secondary two students' metacognitive skills in solving problems in circle geometry.

Introduction

Geometry is a branch of Mathematics that deals with space and shapes characterised by lines and angles. It has been proven to be one powerful means of improving spatial abilities, an important component of human intelligence (Paul & Ayishabi, 2016). Apart from enabling students to understand and establish relationships between lines, shapes and spaces, it helps them to associate geometric patterns in the universe with several branches of Mathematics (Chukuemeka, Nwaneri & Nsigbe, 2017). The learning of geometry also enables students to develop skills of conjecture, deductive reasoning and spatial understanding. These are enhanced when they use metacognitive skills to plan, monitor and evaluate their thought processes in solving problems in geometry.

Metacognition is a thinking process that enables students to understand and give reasons for their steps in learning geometry. According to Charles-Ogan (2014), it is a second order cognition that encompasses thoughts about knowledge. Igbal, Sultana and Afzal (2017) noted that the term focuses on knowledge of cognitive processes and strategies. It regulates cognitive processes such as learning, problem solving, comprehension, reasoning and memory when students engaged in cognitive task in geometry (Tuncer & Kaysi, 2013; Amin & Sukestiyarno, 2015; Bot, 2017). Metacognitive knowledge is the knowledge about oneself and the factors that might affect strategies of solving a problem. According to Lai (2011), John Flavell categorised metacognition knowledge into three. First, the person variables which deals with what one recognises about strengths and weaknesses in learning and processing information. Second, the task variables which focuses on what one knows about the task and processing demands required to complete a task. Third, the strategy variables which concentrates on the strategy one has at hand to apply in different ways to successfully complete a task. Moreover, metacognitive regulation as a component of metacognition monitors a student's cognition in terms of planning activities, awareness of how to carry out task, and evaluation of processes and strategies involved in carrying out task.

According to Abdellah (2015), "metacognition knowledge can be described as what we know about our cognition process" (p.561). Metacognition knowledge is characterised by declarative knowledge (content knowledge), procedural knowledge, and knowledge of the condition (strategy knowledge). Students understanding of geometric aspect of Mathematics (content knowledge) is necessary for them to grasp their own weaknesses and strengths (capabilities). Also, how they perceive the difficulty of the task (procedure knowledge) enhances their knowledge of procedures involve in carrying out the task. Again, knowledge about their own capabilities for using strategies to learn (strategy knowledge) is very important. Altindag and Senemoglu (2013) explained that the most important difference to be emphasised is between metacognitive knowledge and metacognitive experiences. These metacognitive skills are critical in enhancing students' metacognition skills in geometry. There are processes that students need to meticulously follow in order to enhance their understanding of concepts at the metacognition level. According to Papaleontiou-Louca (2014), they are planning, monitoring, and regulating of thoughts. Also, they are known as executive processes which involved the interaction at two levels. At one level is the creative, associative, wandering mind and above it, is the executive, trying to keep it on task. Audu and Amakor (2015) stressed that awareness of strategies enhance understanding the problem, organising the given information and formula, plan solution attempts, evaluation of plans, monitor progress and verifying final result. Şahin and kendir (2013) observed that metacognitive processes commonly develop slowly with age on their own, but instruction is much more effective in the development of metacognitive skills when compared to maturing. Consequently, Mathematics teachers are expected to organise the learning environment in a way that it will help students to improve their metacognitive processes. According to Erickson (2015), this would improve their metacognition in areas of problem solving, reading, writing, self-regulation, technology, comprehension, metacognitive strategies, self-regulated learning, tutoring and measurement. In fact, some studies have shown that metacognitive processes make students to understand mathematical concepts as they perform better in Mathematics reading and cognitive tasks (Lin, Wei & Chang, 2015; Amin & Sukestiyarno, 2015). Other studies suggested that all categories of students; high achievers and low achievers, benefit from metacognition strategies in geometry and indeed Mathematics (Vijayakumari & D' Souza, 2013; Hasbullah, 2015).

Many research in the area of metacognition point to the fact that metacognitive strategies enhance students' retentive ability in geometry (Audu & Amakor, 2015; Akaazua, Bolaji, Kajuru, Mu, Musa & Bala, 2017). Studies (Lai, Zhu, Chen & Li, 2015; Amin & Sukestiyarno,2015; Baltaci, Yildiz & Özcakir, 2016) have shown that a positive linear relationship exists between metacognitive awareness and cognitive skills in Mathematics, between metacognitive awareness Levels and grade levels in Mathematics. Research findings (Vijayakumari & D' Souza, 2013; Wonu & Ogunkunle, 2015; Audu & Amakor, 2015; Hasbullah, 2015) revealed that metacognitive strategy and metacognitive-cooperative learning approach significantly enhance achievement of students in Mathematics. But Fior (2015) found that metacognitive strategy did not demonstrate significant improvement in metacognition of students in Mathematics. Some studies showed that metacognitive strategies play a critical role in enabling students to develop positive attitude toward learning geometry (Şahin & kendir, 2013; Enki, 2014).

In terms of gender, studies revealed that both male and female students benefitted from the use of metacognition strategies in teaching geometry (Zakariyya, Ndagara & Yahaya,2016; Essien & Ado (2017). However, some studies using Jigsaw IV cooperative learning, learning outcomes, and Rusbult problem solving model showed that that there was a significant difference in the achievement of male and female students in geometry in favour of males (Timayi, Ibrahim & Sirajo, 2016; Banus, Waziri & Buba, 2016; Iji & Obarakpo, 2017). Therefore, gender issue could be explored in the area of metacognition of students in geometry using elaboration strategy.

According to Reigeluth (2012), elaboration strategy is a strategy that focuses on sequencing of contents from simple to complex. It is derived from Elaboration Theory which was propounded by Charles Reigeluth in 1979. Pappas (2014) stated that the organisation of the teaching and learning processes, in elaboration strategy, is done in such a way that the students are active in the step-by-step processes while the teacher serves as a guide. Accordingly, Elsayed (2015) explained that an elaboration is a portion of instruction which provides more detailed or complex knowledge about a part of contents to be taught. A primary-level elaboration elaborates on a part of the epitome and a secondary-level elaboration gives details on a part of a primary-level of elaboration.

Pham's (2015) study explained the following seven interconnected steps. The first step is Sequence (elaboration sequence). This entails splitting of the contents of geometry into conceptual, procedural and theoretical. Conceptual content focuses on sets of materials having common characteristics as procedural content deals with sets of actions that help to reach a goal while theoretical content handles principles. The second step is Organisation. At this stage, learning materials in geometry are organised from the simple to the complex. The arrangement is such that prerequisites come before the main content. For instance, on geometry, plane geometry comes before cycle geometry. Summarisation is the third step of elaboration strategy (Tay, 2013). In the course of planning the lesson in geometry, the main concepts are noted and highlighted. That is, during the lesson, the main points of the lesson are emphasised. Synthesis is another step of the elaboration strategy. At this level, the concepts taught are harmonised. Different concepts taught in geometry are fused in order to form a whole. This means that the concepts learned are then integrated to each other. The fifth step is Analogy (Tay, 2013). At this step, teachers use relevant concepts in geometry to explain another concept during a lesson. Also, teachers bring to the class some familiar concepts for discussion to define a new concept. The use of Cognitive-Strategy Activator constitutes the sixth step. During lesson, students are exposed to a situation where cognitive skills are required. Pictures or diagrams are used by teachers to enhance students' interaction in the class when learning geometry. The seventh step of the elaboration strategy is Learner Control or study control (Salwah & Ashari, 2016). Teacher gives opportunity for the students to control the sequence of information when learning geometry. Students are allowed to ask questions, respond to questions, and to do their class work. Thus the steps of the strategy enable students to enjoy its benefits in learning in geometry.

According to Hamidi, Khoshbakht and Abdolmaleki (2011), the following are values of elaboration strategy. First, this strategy enables the teacher to sequence concepts to be taught in such a way that it starts from simple to complex. This facilitates sequencing of instruction in such a way that the ideas are related for meaning-making. As teachers plan contents in such a way that what is simple is taught before what is complex, the easily improve on the entire content or curriculum. Setiasih (2015) noted that it is done "to activate the students' prior knowledge about the world and to improve their critical thinking and logical reasoning" (p.35). So the teaching strategy helps teachers to improve on their teaching plan. This helps students to ask questions while studying about how things work and why, and then they find the answers in their class materials and discuss them with their classmates (Weinstein, Smith & Caviglioli, 2016). Also, as students elaborate, they make connections between different ideas to explain how ideas work together. In fact, the effectiveness of elaboration strategy has been proven in the areas of performance, achievement and critical thinking skills of students (Elsayed, 2015; Salwah & Ashari, 2016; Guwam & Gwandum, 2017). Hence, the need for this study to determine the effectiveness of elaboration strategy in the area of metacognition in geometry.

Statement of the Problem

Objectives of teaching geometry at the senior school level are being threatened by the perennial weaknesses recorded in geometry during SSCE in Mathematics conducted by WAEC chief examiners (WAEC, 2017; WAEC, 2018). Students use inappropriate methods of solving geometric problems which contribute to unsatisfactory achievement of students in Mathematics. The problem is compounded by the use of conventional strategy which makes the students to depend on their teachers to the extent that they develop lukewarm attitude towards learning tasks. Many of them have develop lackadaisical attitude towards learning activities like asking and answering questions in class, doing their classwork and homework, test and examination, as they become depend on others and malpractice during classwork, assignments and examinations. In fact, students consider geometry as difficult and dread geometric aspect of Mathematics (Fabiyi, 2017). These affect their conceptual understanding of geometry to the extent that many of them hold misconceptions of geometry (Sam-Kayode & Salman, 2016). Again, in the course of learning geometry, teacher guides students to understand and apply geometric theorems which explain facts about a content or topic. For instance, when it comes to learning geometric aspect of Mathematics, some students find it difficult to understand and recollect those technical vocabularies such as 'angle at centre twice angle at circumference', or 'the opposite angles of a cyclic quadrilateral are supplementary'. They do not appropriately use their metacognitive skills in solving problems in geometry, as they find it difficult to plan, monitor and evaluate their strategy. Indeed, they find it difficult to understanding a problem and apply appropriate strategy when solving problem in geometry (Yaks & Zuya, 2016).

Considering these problems, there is need for Mathematics teachers to adapt teaching strategies that would engage and enhance students' metacognition in geometry. Therefore, the study investigated the effect of elaboration strategy on metacognition of senior secondary two (SS2) students in geometry.

Aim and Objectives of the Study

The aim of this research was to determine the effects of elaboration strategy on metacognition of SS2 students in geometry in Langtang North, Plateau State, Nigeria. Specifically, it sought to:

1. determine the metacognition status of SS2 students in the experimental and control groups.
2. find out the metacognition status of male and female SS2 students in the experimental group.

Research Questions

The following research questions were formulated in the study:

1. What is the difference between the metacognition of SS2 students in geometry when taught with elaboration strategy and conventional strategy?
2. What is the difference between the metacognition of male and female SS2 students in geometry when taught using elaboration strategy and conventional strategy?

Hypotheses

The following null hypotheses were tested at 0.05 level of significance:

1. There is no significant difference between the metacognition of SS2 students in geometry when taught with elaboration strategy and conventional strategy.
2. There is no significant difference between the metacognition of male and female SS2 students in geometry when taught using elaboration strategy.
3. There is no significant interaction effect of strategy and gender on the metacognition of SS2 students in geometry.

Methodology

The quasi-experimental design of the non-equivalent control group design was adopted for the study. The population of the study was 1362 Senior Secondary Two (SS2) students in the 22 registered private schools in Langtang-North Local Government Area (LGA) of Plateau State, Nigeria. It comprised 730 males and 632 females in SS2. The choice of the population was because most of the previous studies dealt with public schools, and the research wanted to find out the situation in private schools. The choice of SS2 was based on the fact that circle geometry formed part of the Mathematics content of SS2 and the class had learned plane geometry. A sample of 175 SS2 students (represented 13% of the population) participated in the study. It comprised 90 males and 85 females from 3 out of the 22 private senior secondary schools in the study area which were randomly chosen. Each of the sampled schools had two arms. One of them was assigned to the experimental group while the other was tagged the control group. A three-stage cluster sampling technique was used to select the schools from the following clusters: State Constituencies, Districts, and Private schools. The technique was used to sample three schools from the private schools in the study area. The three sampled schools were coded 01,02 and 03 respectively. Intact classes were assigned to either the experimental group or control group through balloting. Data were collected using Metacognition Scale in Geometry (MSG). The MSG is an adapted questionnaire from Zepeda (2015). It was a 7-point scale but it was modified to a 4-point scale to get specific responses on metacognition skills of senior school students in circle geometry, and to suit their level. Section A sought information on gender while section B consisted of 24 items which elicited information on metacognition skills of a student in geometry. The questionnaire sought information on the degree to which students used various metacognitive skills. It was based on a four-point scale as Strongly Agree (SA), Agree (A), Disagree (D) and Strongly Disagree (SD).

Items of MSG were scrutinised by three experts, each in Psychology, Measurement and Evaluation, and Mathematics. They checked contents of the instrument to ensure that it measures the construct. The experts are lecturers from the University of Jos. The reliability of MSG (0.91) was obtained using Cronbach's Alpha because the scores were not dichotomously scored. To ensure stability, a test re-test analysis was done using Pearson Product Moment Correlation and it yielded 0.72. The study involved three research assistants who were all graduates employed to teach Mathematics in the sampled schools. They were all trained for four hours on how to use the lesson plan designed based on elaboration strategy. Before the treatment, the Pre-MSG was administered to the participants. The experimental group was taught using the Elaboration Strategy Lesson Plan (ESLP) while the control group was taught using the Conventional Strategy Lesson Plan (CSLP) by the trained research assistants. The groups were taught by the same research assistant in a school. However, while a research assistant was with one group, the other group was engaged by another teacher. The treatment lasted for four weeks. After the intervention, the post-MSG was administered to the experimental and control groups simultaneously by the research assistants. The scoring of MSG was done using four-point scale as Strongly Agree (SA), Agree(A), Disagree (D), and Strongly Disagree (SD), the items were scored 4 points, 3 points, 2 points, and 1 point for responses SA, A, D and SD respectively. The scores of each of the students on the instrument was scored out of hundred.

The data collected were analysed using Statistical Packages for Social Sciences (SPSS) version 20 tools such as mean, standard deviation, and Analysis of Covariance (ANCOVA). All the research questions were answered using mean and standard deviation. Each of the 3 null hypotheses was tested at 0.05 level of significance using ANCOVA.

Results

Research Questions

Research Question 1

What is the difference between the metacognition of SS2 students in geometry when taught with elaboration strategy and conventional strategy?

Table 1: Metacognition Mean Scores and Standard Deviations of the Experimental and Control Groups

Group	Number	Pre-Test		Post-Test	
		Mean	Std. dev.	Mean	Std. dev.
Experimental	77	61.5325	9.6894	66.7662	9.9073
Control	98	60.5612	10.3117	63.7245	10.2492

Table 1 shows that the pre-test metacognition mean and standard deviation of the experimental group were 61.5325 and 9.6894 respectively and their post-test mean and standard deviation were 66.7662 and 9.9073 respectively. For the control group, the pre-test metacognition mean and standard deviation were 60.5612 and 10.3117 respectively, while their post-test metacognition mean and standard deviation were 63.7245 and 10.2492 respectively. The mean difference between the two groups in the pre-test was 0.9712, but the mean difference in the post-test was 3.0417.

Research Question 2

What is the difference between the metacognition of male and female SS2 students in geometry when taught using elaboration strategy and conventional strategy?

Table 2: Metacognition Mean Scores and Standard Deviations of the Experimental and Control Groups based on gender

Group		Pre-Test		Post-Test	
	Number	Mean	Std. dev.	Mean	Std. dev.
Male(Experimental)	45	61.3778	10.2565	66.7778	9.4746
Male(Control)	45	61.1111	11.1991	65.5111	11.6904
Female(Experimental)	32	61.7500	8.9875	64.7500	10.6408
Female(Control)	53	60.0943	9.5782	62.2075	8.6721

Table 2 reveals that male students in the experimental group had mean scores of 61.3778 and 66.7778, and the standard deviation scores of 10.2565 and 9.4746 in pre-test and post-test respectively while male students in the control group had mean scores of 61.1111 and 65.5111 and standard deviation scores of 11.1991 and 11.6904 respectively. The female students in experimental group had mean scores of 61.7500 and 64.7500 and standard deviation scores of 8.9875 and 10.6408 in the pre-test and post-test respectively as against mean scores of 60.0943 and 62.2075 and standard deviation scores of 9.5782 and 8.6721 of the female students the control group.

Hypotheses

Hypothesis 1

There is no significant difference between the metacognition of SS2 students in geometry when taught with elaboration strategy and conventional strategy.

Table 3

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	12278.791[a]	2	6139.396	183.027	.000
Intercept	1008.564	1	1008.564	30.067	.000
Pre-MSG	11879.836	1	11879.836	354.160	.000
Group	215.924	1	215.924	6.437	.012
Error	5769.517	172	33.544		
Total	758854.000	175			
Corrected Total	18048.309	174			

a. R Squared = .680 (Adjusted R Squared = .677)

Table 3 reveals that F(1,172) = 6.437, P = .012; P < .05. Therefore, the null hypothesis of no significant difference between metacognition of SS2 students in geometry when taught with elaboration strategy and conventional strategy was rejected. It implies that there was a significant effect of elaboration strategy on the metacognition of SS2 students in geometry.

Hypothesis 2

There is no significant difference between the metacognition of male and female SS2 students in geometry when taught using elaboration strategy.

Table 4: ANCOVA of Metacognition Scores in the Experimental Group based on Gender

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	5129.676[a]	2	2564.838	81.454	.000
Intercept	388.874	1	388.874	12.350	.001
Pre-MSG	5129.662	1	5129.662	162.908	.000
Gender	2.205	1	2.205	.070	.792
Error	2330.116	74	31.488		
Total	350705.000	77			
Corrected Total	7459.792	76			

a. R Squared = .688 (Adjusted R Squared = .679)

Table 4 reveals that F(1,74) = .070, P = .792; P > .05. Hence, the null hypothesis of no significant difference in metacognition of male and female SS2 students in geometry when taught using elaboration strategy was retained. It means that the effect of gender on the metacognition was not significant in the experimental group.

Hypothesis 3

There is no significant interaction effect of strategy and gender on the metacognition of SS2 students in geometry.

Table 5: ANCOVA of the interaction effect of strategy and gender on the metacognition of SS2 students in Geometry

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	12379.597[a]	4	3094.899	92.813	.000
Intercept	1031.629	1	1031.629	30.938	.000
Pre-MSG	11782.734	1	11782.734	353.355	.000
Group	191.941	1	191.941	5.756	.018

Gender	58.350	1	58.350	1.750	.188
Group* Gender	29.865	1	29.865	.896	.345
Error	5668.711	170	33.345		
Total	758854.000	175			
Corrected Total	18048.309	174			

a. R Squared = .686 (Adjusted R Squared = .679)

Table 5 shows that there is no significant interaction effect of strategy and gender on metacognition of SS2 students in geometry (F1, 170= .896, p=.345; p >.05). It means that strategy and gender did not jointly have significant effect on SS2 students' metacognition in geometry.

Discussion

The discussion is presented under the following captions:

Elaboration strategy and senior secondary students' metacognition in geometry

The study indicated that the metacognition mean scores of the experimental group was higher than that of the control group (Table 1). In fact, it was observed that elaboration strategy had significant effect on students' metacognition in geometry (Table 3). The finding supports that of Sahin and Kendir (2013) who revealed that using metacognitive strategy significantly enhance performance of students in geometry. Also, the finding agrees with those studies (Vijayakumari & D' Souza, 2013; Wonu & Ogunkunle, 2015; Audu & Amakor, 2015; Hasbullah, 2015) who observed that metacognitive strategy and metacognitive-cooperative learning approach significantly enhance achievement of students in Mathematics. Again, the finding supports the views of Lai, Zhu, Chen and Li (2015) as well as Amin and Sukestiyarno (2015) that a positive relationship between metacognitive skills and Mathematics achievement exists. On the contrary, the finding is inconsistent with that of Fior (2015) who found that metacognitive strategy did not demonstrate significant improvement in metacognition of students in Mathematics.

Effect of gender on students' metacognition in geometry

The finding showed that the male students' post-test mean metacognition score was higher than that of the female students (Table 2), but the difference in metacognition mean scores of male and female students was insignificant (Table 4). The finding relates to that of Baltaci, Yildiz and Ozcakir (2016) who worked on metacognitive awareness level, and found that a positive relationship exists between gender and learning style. Also, findings of Wonu and Ogunkunle (2015) as well as Audu and Amakor (2015) suggested that gender has no significant effects on the metacognitive planning skills of participants in Mathematics when exposed to metacognitive strategy. Again, these findings (Iqbal, Sultana & Afza, 2017; Zakariyya, Ndagara & Yahaya, 2016; Essien & Ado, 2017; Akaazua, Bolaji, Kajuru, Mu, Musa & Bala, 2017) on metacognitive strategy, mastery learning, Mathematics puzzles and concrete manipulatives corroborate the finding that no significant gender difference in the metacognition of students after exposure to elaboration strategy. But the finding of this study is in disparity with the findings of Charles-Ogan (2014) who explored metacognitive skills and misconception of students, and found that female students had reduced misconception when compared to their male counterparts. However, Timayi, Ibrahim and Sirajo (2016), Banus, Waziri and Buba (2016) as well as Iji and Obarakpo (2017) in their separate studies using Jigsaw IV cooperative learning, learning outcomes, and Rusbult problem solving model found that male students had a significant achievement mean scores when compared to their female counterparts.

Summary of Findings

1. SS2 students' metacognition in geometry in the experimental group was significantly higher than that of their counterparts in the control group.
2. There was no significant difference between male and female SS2 students' metacognition in geometry when taught using elaboration strategy.
3. There was no significant interaction effect of strategy and gender on the metacognition of SS2 students in geometry.

Conclusion

Elaboration strategy was found to be more effective than the conventional strategy in enhancing senior secondary two students' metacognition in circle geometry. Though there was no significant difference between the metacognition of male and female SS2 students in geometry when taught using elaboration strategy, the male students' metacognition mean score was greater than that of their female counterparts.

Recommendations

In line with the conclusion of the study, the following recommendations are made:

1. Mathematics teachers should use the strategy to enhance senior secondary two students' metacognitive skills in solving problems in geometry.
2. Ministry of Education should organise seminars, workshops and conferences on the use of elaboration strategy in teaching geometry for serving teachers.

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