Effect of 7Es Instructional Cycle on Senior Secondary Mathematics Students Learning Outcomes in Gusau, Zamfara State, Nigeria

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ABSTRACT

The study investigated the effects of 7Es instructional cycle on senior secondary mathematics school students learning outcomes in Gusau, Zamfara State, Nigeria. A pre-test post-test quasi experimental research design was adopted where two research questions and two null research hypotheses guided the study. The target population was 6,466 (3,154 male and female 3,312). The sample consists of 216 (103 male and 113 female) senior secondary school two mathematics students using an intact class. A total of 40 multiple choice objective questions were used for data collection at pre-intervention test and post-intervention test. Geometry Achievement Test (GAT) was instrument developed for the study. The instrument was validated by experts and pilot tested. A reliability coefficient of 0.75 was obtained for Geometry Achievement test using Pearson Product Moment Correlation (PPMC) and the instruments were reliable for the study. Mean and Standard Deviations was used to answer the research questions and Analysis of Variance (ANOVA) was used for testing the hypotheses at 0.05 level of significance. Findings revealed that there was significant difference in the mean achievement scores of senior secondary school male and female students taught mathematics using 7Es instructional cycle strategies and those taught with lecture method. that there was significant difference in the mean retention scores of senior secondary school male and female students taught mathematics using 7Ess instructional cycle strategies and those taught with lecture method. It was recommended among others that Geometry teacher's awareness of 7Es instructional cycle of teaching should be created through workshops, seminars and conferences on teaching strategies.

Keywords: 7Es instructional cycle, learning outcomes, gender, Mathematics

INTRODUCTION

Science and Technology is critical to the overall development of any nation is acknowledged worldwide, and some scholars have attested to this importance. For example, Ojo (2016) posited that any nation with a scientifically uneducated citizenry cannot be expected to make any reasonable socio-economic and political decisions. Alordiah et al. (2015) observed that the current development in science and technology has greatly affected the average citizen's lives to be ignorant based on this development is to live an empty, meaningless and hence unrealistic life.

Science Education can be seen by the society as learning science by acquiring and developing conceptual and theoretical knowledge through scientific inquiry and problem solving. Science Education is one of the areas in the wider world, which shapes and moulds the character of teachers and learners in the 21st century, especially in technologies that have revolutionized the way we think and live. Technology is no longer a story, it is now with us as a people in Nigeria (Alemneh, 2022). According to Omwirhiren (2015) science is that

organized body of knowledge, which ensures the ability to acquire skills. It is a search for meaning or exploration of events in nature. Science and technology-related subjects that would enable students to have a substantially greater understanding of science and be able to apply scientific knowledge in solving problems in the ever-changing society, are Mathematics, Physics, Biology, Health Science, Introductory Technology and Chemistry. It is imperative therefore, that young people preparing for such a world, which is becoming more and more exciting and challenging, should leave school well knowledgeable in science.

Consequently, the broad goal of secondary school education as stated in the National Policy on Education (FGN, 2014) is to prepare an individual for useful living in society and higher education irrespective of gender, social status ,religious or ethnic background. One of the objectives of establishing secondary school education, as stated in the National Policy on Education, is to equip students to live effectively in the modern age of Science and Technology. One of the main objectives of science instruction in schools is the enhancement of conceptual understanding, which can explain a concept taught in one's own words having understood it well. Thus, research in science education has shifted from teacher-centered to student-centered, consequent upon factors in students' minds such as prior knowledge, memory capacity and cognitive styles (Gongden, 2015). All branches of science have important contributions to making Nigeria technological advanced; one of such science subjects is mathematics.

Mathematics has been regarded as an essential and integral part of science education whose importance is needed in everyday life. Mathematics plays a major role in technological advancement hence is referred to as the queen of all sciences as it can also be seen in all facets of life and in day-to-day occupations such as internet technology, banking, medicine, scientific discoveries and even in the planning of daily activities. It is one of the reasons why Mathematics remains a core subject in both primary and secondary schools (Ajibola, 2014). Without a credit pass in Mathematics at senior secondary school level, no student can access tertiary education in Nigeria at tertiary level, Mathematics is offered as a general subject and requirement for graduation for all science students in tertiary, hence the Federal Government of Nigeria (FGN, 2014) in her National Policy on Education placed Mathematics as a core subject that all secondary school students must offer at both junior and senior secondary school certificate levels. In spite of this emphasis, mathematics achievement by secondary school students seems to have remained very poor. Literature is replete with evidence of poor mathematics achievements. Abdullahi (2015) observed that students' performance in Mathematics is low because Mathematics students are not acquiring the skills and understanding they needed to participate effectively in the culture, political and scientific environment later in future. For example, West African Examination Council (WAEC) Chief Examiners' annual report in Mathematics (WAEC, 2018-2022) respectively revealed poor mathematics achievement by secondary school students. In addition, the reports further revealed that students were weak in answering geometrical concept questions.

Efforts have been made in the past to solve the problem of poor Mathematics achievement. These include individualized instruction, extended day programs, flexible grouping and the use of calculator in solving Mathematics questions (Osuafor and Orji, 2017). Abonyi and Nweke (2014) found out that cooperative learning strategy, mathematical game and explicit instruction are among strategies that reduces poor performance in mathematics. Though these methods and strategies have been found to be efficacious for teaching Mathematics, secondary school students mathematics achievement still remain poor. The implication is that there is need for further investigation on how to improve students' achievement in Mathematics.

As an aspiration for science educators to improve students' engagement in the classroom and facilitate the role of the teachers through the use of more effective instructional strategies, science education researchers are trying to develop student-centered instructional strategies over the years (Balta and Sarac, 2016). One way to conduct student-centered courses is to use learning cycles which allow instructors to put teaching into series of planning strategies.

All proposed learning cycles in the literature, are a consequence of constructivist learning theory which basically asserts that students construct their own knowledge. Learning cycles enables teachers to conduct a series of activities that are meaningful for students and help students to practice for their thinking skills.

Several versions of the learning cycles appear in the literature ranging from 3E's (Exposure, Experience and Engagement), 5E's (Engage, Exploration, Explanation, Expansion and Evaluate) and 7E's (Excitement, Exploration, Explanation, Expansion, Extension, Exchanging and Evaluation). Lately, 9E's learning cycle is also proposed (Khashan, 2016). Each ''E'' letter in the learning cycles stands for the capital letters of English words which indicates phases of learning process (Balta and Sarac, 2016). Starting from 3E, each next cycle of the model is an expansion of the prior model. For instance, 7E cycle differs from the 5E in two ways. The engage phase in 5E is expanded into elicit and engage. Thus, more emphasis is placed on prior understanding and tacit knowledge that can be used as a basis for the learning to take place.

Similarly, elaborate and evaluate phases are expanded into elaborate, evaluate and extend phases. "The addition of the extend phase to the elaborate phase is intended to explicitly remind teachers of the importance for students to practice the transfer of learning" (Balta & Sarac, 2016). It was also proposed that elicit, engage, explore, explain, elaborate, evaluate, and extend discrete elements for the 7E learning cycle and "research on how people learn and the incorporation of that research into lesson plans and curriculum development demands that the 5E model be expanded to a 7E model". The primary aim of the 7E learning cycle is to highlight the increasing importance of provoking previous understandings and transferring the concepts to new contexts in other to solve the lingering problems faced by students in Mathematics.

However, Learning outcomes in Mathematics entail students' academic achievement in Mathematics which cannot be separated from problems in Mathematics.

Several researchers such as; Abdullahi et al. (2021) have worked on students' achievement level but the results were inconclusive, George et al. (2017) stated that instruction can be organized in such a way and manner that all students in the class could perform and retain Mathematics knowledge better.

Retention is another dependent variable to be use in this study; retention has been described by the Macmillan school dictionary as the ability to remember ideas and facts. Ajibola (2014) wrote that retention could be measured through verbal recall of learnt materials. Retention of concepts learnt assist in influencing effective thinking is one thing to be taught mathematics, specifically geometry, via appropriate strategy; it is another thing to remember after some reasonable period must have elapsed. Several studies have indicated that teaching methodology can improve learners' retention levels. For instance, Abdullahi (2015) pointed out that self-learning leads to better retention of information and the development of a favorable attitude toward science and technology. The condition of keeping something/facts you may be able to memorize in the short-term and long term, all depends on the method of learning, environment and gender.

Gender on the other hand refers to the socially built jobs, practices, exercises and traits that a given society thinks proper for people World Health Organisation (W.H.O, 2017). For quite a while, gender was recorded by scientists as one of the variables that affected the academic performance of the child (Hyde et al., 2019 and Muschkin, et al., 2020). Therefore, in the light of the great importance to teach and learn mathematical concepts and the difficulties that students encountered in learning concepts during their different stages of learning, interest has appeared to develop the teaching of mathematics curricula through the implementation of different flexible educational methods and theories in different actual learning situations (Fouze et al., 2017).

Also, attention has increased in search for new teaching strategies that help reduce and overcome the difficulties in the teaching and learning process and achieve the main objectives of learning the mathematical concepts, which enable students to realize such concepts and develop them. Some of the teaching methods that could achieve this objective are those that have adopted what the constructive theory has offered, which concentrates on the students' activity and effectiveness in the learning situations. Khaled (2016) pointed out that this theory is considered as one of the most influential theories that focused on the learner's cognitive structure, where it believe learning to be active process in building knowledge and focused on the process that takes place in the learner's brain during the learning situation, where the learner establishes a relationship between the new knowledge and his previous knowledge. The study is therefore designed to determine the

effects of 7Es instructional cycle on senior secondary mathematics students' learning outcomes in Gusau, Zamfara State, Nigeria.

Statement of the Research Problem

Over the years, students' performance in Mathematics generally has been quite unsatisfactory. The external examining bodies such as West Africa Examination Council (WAEC) and National Examination Council (NECO) have repeatedly recorded inconsistence performance in Mathematics by students. The report of the chief Examiner, West Africa Examination Council (WAEC) 2022 revealed that candidates enrolment and performance in Gusau, Zamfara State for the years 2019- 2022 showed the performance of the candidates were inconsistence. According to the Chief Examiner, the persistent inconsistency performance from the years 2019- 2022 resulted from poor understanding of general principles and geometrical concepts which were difficult for the candidates' because majority of them were reported to be shunning away from answering questions in geometry.

Research studies of (Awofala, 2019) have shown a persistent low achievement in SSCE Mathematics examinations annually. This low achievement in Mathematics could be attributed to poor instructional delivery approaches adopted by teachers and students' attitudinal problems. Consequently, curriculum developers have recommended some teaching approaches that are learner-centered for the effective teaching and learning of the subject to bring the expected desired learning outcomes. Despite the recommendation for using these approaches by curriculum developer in teaching Mathematics, students' achievement in the subject continue to be discouraging (Larina and Kapuza, 2020). The persistent low achievement of students in Mathematics, specifically in Geometrical concepts at senior secondary certificate examination, raises doubt about the effectiveness of current teaching approaches used by Mathematics teachers.

Against this premise, exposing learners to the understanding of basic concepts in Mathematics and achieving desirable outcomes requires the use of creative, innovative and interactive teaching approaches such as 7Es learning cycle that may arouse the interest of the learners and demystify difficult concepts in core subjects like Mathematics ought to focused. Therefore, the study examines the effects of 7Es instructional cycle on senior secondary mathematics students' learning outcomes in Gusau, Zamfara State, Nigeria.

Aim and Objectives of the Study

The aim of this study is to determine the effects of 7Es instructional cycle on senior secondary mathematics school students learning outcomes in Gusau, Zamfara State, Nigeria. Specifically, the objectives are to:

1. Determine the achievement scores of male and female students taught mathematics using 7Es instructional cycle strategy
2. Find out the mean retention scores of male and female students taught mathematics using 7Es instructional cycle strategy.

Research Questions

The following research questions were raised for the study.

1. What is the mean achievement scores differentiate male and female students taught mathematics using 7Es instructional cycle strategy?
2. What is the difference in the mean retention scores of male and female students taught mathematics using 7Es instructional cycle strategy?

Null Research Hypotheses

The following null hypotheses were formulated and tested at 0.05 alpha level of significance.

HO_1: There is no significant difference in the mean achievement scores of male and female students taught mathematics using 7Es instructional cycle strategy.

HO_2: There is no significant difference in the mean retention scores of male and female students taught mathematics using 7Es instructional cycle strategy.

RESEARCH METHODOLOGY

The study adopted quasi-experimental research design (Non-equivalent, Non-randomized and Experimental-Control group design). A quasi-experimental design is a type of design that aims to establish a cause and effect relationship between an independent and dependent variable. However, the quasi-experimental design does not rely on random assignment. Instead, subjects are assigned to groups based on non-random criteria. The population for this study was the entire 17,106 students in the Private senior secondary school of 2023/2024 session in main capital city of Gusau, Zamfara State as a result of insecurity in the State. The target population is 6, 466 (3,154 male and female 3,312). Senior secondary school Mathematics students in SSII. The choice of SSII is based on the fact that the aspect of Mathematics concepts focused on difficult areas in Geometry. Students for the 2022/2023 session were used for the study.

The sample size of the study was 216 (103 male and 113 female) of the entire SS II mathematics students in Private senior secondary schools in Gusau, Zamfara State. Subsequently, the schools were purposively selected due to insecurity bedwelling the state most especially the three senatorial zones which were the focus of the study. Other reason for selecting private schools was that they are operated with the same environmental conditions, such as workforce, gender composition and school type (private schools). Separate schools were used for the research study to avoid the interaction of subjects during and after the treatment process. An entire class were selected randomly from each of the arms in the sampled schools and used for the study.

Geometry Achievement Test (GAT) and Geometry Retention Test (GRT). Geometry Retention Test was developed through the randomization of Geometry Achievement Test (GAT) that is, the questions numbers and options were reshuffled. Geometry Achievement Test (GAT) instrument was validated by two experts. To test the (GAT) reliability, a random sample of 40 Mathematics (SS-II) students who were not part of the leading study group were selected. The test was administered on the pilot sample. Two sets of data were collected using the Test-Retest method and then analyzed. The Geometry Achievements Test (GAT) reliability coefficient was determined as 0.75 using Pearson Product Moment Correlation (PPMC).

The data obtained from administration of instruments was analyzed using descriptive and inferential statistics. Mean and standard deviation was used to answer the research questions one to eight. Pretest scores was analysed using Analysis of Variance (ANOVA). Analysis of Variance (ANOVA), was used to test the hypothesis at 0.05 level of significant. The data was analysed using Statistical Package for Social Sciences 23.0 (SPSS 23.0).

RESULTS AND DISCUSSION

Research Question One: what is the difference in the mean achievement scores of male and female students taught mathematics using 7Ess instructional cycle strategy and those taught with lecture method?

Table 1: Mean and SD Results of Achievement Scores of Male and Female Students Taught Mathematics Using 7E Cycle.

Group	**N**	**Pretest**		**Posttest**		**Mean Gain**
		Mean	**SD**	**Mean**	**SD**	
Male	31	24.77	7.205	58.94	12.524	34.17
Female	41	26.15	10.546	49.90	14.906	23.75

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Table 1 presents the mean, standard deviation and mean gain of male and female students in 7E Cycle Instructional Strategy. The result shows that male taught 7E Cycle Instructional strategy had pre-test means of 24.77 and post-test mean of 58.94 with standard deviation of 7.205 and 12.524 respectively, a mean of (34.17) was gained, while female in 7E instructional strategy had pre-test means of 26.15 and post-test mean of 49.90 with standard deviation of 10.546 and 14.906 respectively, a mean of (23.75) was gained. Thus, male in 7E cycle had higher mean gain of 34.17 than female in 7E Cycle. This indicates that male in 7E cycle performed better than female in 7E Cycle on Geometry achievement.

Research Question Two: what is the difference in the mean retention scores of male and female students taught mathematics using 7Ess instructional cycle strategy and those taught with lecture method?

Table 2: Mean and SD Results of Retention Scores of Male and Female Students Taught Mathematics Using the 7Es Cycle Strategy

Group	**N**	**Posttest**		**Retention test**		**Mean Gain/Loss**
			SD		SD	
Male	31	58.94	12.52	61.50	13.17	2.56
Female	41	49.90	14.91	53.31	12.50	3.41

Table 2 shows the mean and standard deviation of the posttest and retention test scores of male and female students in 7Es Cycle strategy. The result revealed that the mean and standard deviation of posttest scores of male students was 58.94, standard deviation of 12.52 and 61.50 is the mean score of male students at retention test with 13.17 standard deviation respectively. The mean gain for male students in 7Es is 2.56. Similarly, the mean and standard deviation of the posttest scores of female students was found to be 49.90 and standard deviation of 14.91 while retention test mean score of 53.31 and standard deviation of 12.50 was obtained by female students. The mean gain for female students in 7Es is 3.41. This implies that female students had mean gain higher than the male students in the same group.

Testing of Hypotheses

HO_1: There is no significant difference in the mean achievement scores of male and female students taught mathematics using 7Es instructional cycle strategy and those taught with lecture method.

Table 3: Summary of Independent t-test Analysis of Male and Female Students Taught Using the 7Es Instructional Cycle Strategy

Groups	**N**	**Mean ($\bar{\chi}$)**	**SD**	**Df**	**t**	**P**	**Remark**
Male 7Es	31	58.94	12.52	70	3.65	0.001	Significant
Female 7Es	41	49.90	14.90				

Significant at $P < 0.05$

Table 3 shows the means, standard deviations, and t-test for male and female students' achievement in mathematics, which was significant at $p < 0.05$ with $t = 3.65$. Thus, Null Hypothesis 1 (HO1) was rejected. There was a significant difference between the mean scores of male and female students taught using the 7Es instructional cycle strategy. Male students performed better than their female counterparts.

HO_2: There is no significant difference in the mean retention scores of male and female students taught mathematics using 7Es instructional cycle strategy and those taught with lecture method.

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Table 4: Summary of Independent t-test Analysis of Male and Female Students' Retention Scores Using the 7Es Instructional Cycle Strategy

Groups	N	Mean ($\bar{\chi}$)	SD	Df	t	P	Remark
Male 7Es	31	61.50	13.17	70	2.13	0.037	Significant
Female 7Es	41	53.31	12.50				

Significant at $P < 0.05$

Table 4.19 shows the means, standard deviations, and t-test for male and female students' retention scores, which was significant at $p < 0.05$ with $t = 2.13$. Thus, Null Hypothesis 6 (HO_6) was rejected. There was a significant difference between the mean retention scores of male and female students taught using the 7Es instructional cycle strategy. Male students retained their learning better than their female counterparts.

DISCUSSION OF RESULTS

The study found that there is a difference in the mean achievement scores of male and female students taught 7Es instructional cycle, as the result shows that male in 7Es instructional cycle performed better than female in 7Es Cycle, the female in lecture method performed better than the male lecture groups on Geometry achievement. Also, there was significant difference in the mean achievement scores of senior secondary school male and female students taught mathematics using 7Es instructional cycle strategies and those taught with lecture method. The finding was in dissonance with Akilu and Umar (2023) whose study indicates gender did not significantly affect academic achievement of students when taught using 7Es compared to those taught using lecture method.

The study found that there is difference in the mean retention scores of male and female students taught mathematics using 7Es instructional cycle strategy and those taught with lecture method. This implies that male and female students in 7Es instructional cycle retained better than male and female taught with lecture method. Also, found that there was significant difference in the mean retention scores of senior secondary school male and female students taught mathematics using 7Es instructional cycle strategies and those taught with lecture method. The result Was not in agreement with Akilu and Umar (2023) who's result revealed that there was no significant difference between the mean retention scores of male and female students taught 7Es instructional cycle and those taught with lecture method.

CONCLUSION

It was concluded that a significant difference exists between the mean achievement scores of students taught Geometry with 7Es instructional strategy and Conventional lecture method favouring 7Es instructional cycle. Similarly, a significant difference exists between the mean retention scores of students taught Geometry with 7Es instructional cycle indicating that the experimental group who received Geometry instructions with 7Es instructional cycle on average retained the course contents learnt higher than the one who received the same instruction through conventional lecture method. Additionally, the use of the 7Es instructional strategy would be an effective strategy of learning that could be used to overcome conceptualization problems encountered by students, through the 7Es phases of Elicit, Engage, Explore, Explain, Elaborate Extend and Evaluate also Krulik and Rudnick Problem solving strategy include Read, explore, select a strategy, solve, review and extend). This would certainly solve the perennial problem of low achievement, brought about by students' inability to recall information in examinations.

RECOMMENDATIONS

The following are the recommendations made based on the findings of this study;

1. As established from the findings of this study that 7Es instructional cycle increased the achievement of students, therefore, teachers in secondary secondary schools should be train by the management regarding the capabilities of 7Es instructional cycle.

2. Curriculum developers should incorporate 7Es instructional cycle into mathematics curriculum, this might support mathematics teachers in teaching mathematics.
3. Geometry teacher's awareness of 7Es instructional cycle of teaching should be created through workshops, seminars and conferences on teaching strategies

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