

Programmed Instruction and Students' Comprehension of the Concept of Quadratic Equations in ITU Local Government Area

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ABSTRACT

This study investigated the effect of programmed instruction on secondary school students' comprehension of the concept of quadratic equations in Itu Local Government Area of Akwa Ibom State. The study adopted a quasi-experimental, non-equivalent pre-test post-test control group design. A sample of 104 Senior Secondary Two (SS2) students was drawn from two public co-educational schools using random sampling technique. The instrument for data collection was the *Quadratic Equation Comprehension Test (QECT)*, developed and validated by the researchers with a reliability coefficient of 0.82 using the Kuder-Richardson formula (KR-20). Two research questions and two null hypotheses guided the study. Data collected were analyzed using mean, standard deviation, and independent t-test at 0.05 level of significance. Findings revealed that students taught quadratic equations using programmed instruction achieved significantly higher comprehension scores than those taught using the conventional method. Furthermore, there was no significant difference between the mean comprehension scores of male and female students exposed to programmed instruction. It was concluded that programmed instruction enhances students' comprehension of quadratic equations irrespective of gender. It was recommended that mathematics teachers adopt programmed instructional strategies in teaching algebraic concepts to promote active learning, deeper understanding, and gender inclusivity in mathematics classrooms.

Keywords: Programmed Instruction, Quadratic Equations, Comprehension, Gender

INTRODUCTION

Mathematics is a science of magnitude and number as well as the science that sustains the daily practices of man. It is the only core science subject that acts as a pivot on which national development and wealth of any nation is created (Unodiaku, 2022). Competency in mathematics learning is vital and sustainable to every individual's meaningful and productive life. Mathematics learning is very important in enhancement and sustainability of human existence because mathematics is all about finding solutions to human problems and physical challenges. All these are indications that mathematics is useful in domestic and business deals, scientific discoveries, technological breakthrough, problem-solving and decision making in different situations in life (Usman & Nwoye, 2015; Unodiaku, 2017; National Council of Teachers of Mathematics (NCTM), 2018). Mathematics is one subject that has generated interest consistently over the years as a result of its importance to humanity. It is one of the subjects that is expected to bring about this national development. It is core subject at all levels of education in Nigeria as such students are expected to excel in the subject. This is especially true because the concept of Mathematics plays an important role to an individual day-to-day life and also to the nation at large (Abasi & Ado, 2021). It is a precursor of scientific discoveries and inventions. Since 20th century, mathematics has become the backbone of all scientific investigations and activities. This is to say that the only route to effectively understand the modern world is through mathematics knowledge (D'Ambrosio, 2015; Obodo, 2018). Among the many branches of mathematics that strengthen logical reasoning and problem-solving skills, the study of quadratic equations holds a distinct place for its practical and theoretical importance.

Quadratic equations are polynomial equations of degree two, usually written in the standard form $ax^2 + bx + c = 0$; they describe quadratic functions whose graphs are parabolas and whose algebraic solutions (roots) and vertex carry geometric and analytic meaning (Smith, 2021). According to Johnson (2020), quadratics are central

to algebra because they introduce students to nonlinearity, the relationship between algebraic expressions and their graphs, and methods of solution such as factoring, completing the square, and the quadratic formula, which are tools that build procedural skill and conceptual understanding. In the sciences and engineering, quadratic relations model many everyday phenomena: the vertical position of an object under constant acceleration, the shape of parabolic reflectors and suspension bridge cables, and simple optimization problems such as maximizing area or profit (Davis & Lee, 2019). Mastery of quadratics therefore supports work in physics, engineering, economics, architecture, and computer graphics, and it develops reasoning used in problem formulation and interpretation. Because the topic links symbolic manipulation, geometry, and applied modelling, it is a staple of secondary mathematics and a gateway to advanced study in STEM fields.

Despite its crucial role to man and the society, mathematics continues to be one of the most challenging subjects in schools as perceived by students (Areelu, 2014; Ali & Jameel, 2016, Abasi & George, 2024). There is a general impression that its nature is complicating, as such, students develop phobia in Mathematics that leads to their poor achievement in the subject. Students' dwindling achievement in Mathematics in public examinations is so worrisome and this has led many researchers into investigating the factors that could be responsible for this (Abasi, 2018). As reported by WAEC Chief Examiner report (2023), there has been an abysmal performance of students in Mathematics in West African Senior School Certificate Examination (WASSCE) when compared with other science subjects like chemistry, physics and biology.

Undoubtedly, many aspects influence students' fear, lack of understanding and the resulting poor performances, for example, the attitude of mathematics teachers towards students, the teaching strategies adopted by the teacher and the attitudes and beliefs towards mathematics that are transmitted to them (Abasi & George, 2025; Babayemi, Akpan and Abasi, 2023). These factors, very possibly influence inadequate learning of mathematics and poor achievement in the subject (Cosgaya-Barrera & Castro-Villagr n, 2019). In addition, many researchers are of the opinion that, problems associated with poor performance are due to factors such as poor method of instruction/teaching strategies, lack of adequate qualified and experienced mathematics teachers and lack of laboratory equipment among others are major recurring problems of teaching mathematics in secondary schools (Sani & Salahudeen, 2016; Malik, 2017; Sharma, Fonolahi, Bali & Narayan, 2018).

Furthermore, there is great concern that the low academic achievement of students is more prevalent in secondary school settings where there is continuous use of the conventional lecture method by teachers at this level. This system of teaching calls for the reforming of methods of teaching and application of innovative instructional materials in teaching of Mathematics in order to make it more learner-centered and enhance successful interaction among learners (Adesokan, 2023). To salvage the challenges of students' poor achievement in Mathematics there need for Mathematics teachers to employ innovative teaching strategies for effective teaching and learning. Onose (2007) stated that the teaching and learning of the subject matter requires the discovery of innovations that will promote knowledge retention, which in turn enhances better achievement. In the words of Palin and Lassa in Onose (2007), the teaching of sciences should involve activities that give room for students to think or reason about what they are doing in order to look for relationships, which may enlarge and build a store of scientific techniques.

Programmed instruction is an strategy of presenting new subject matters to students in graded sequence of controlled steps. Students work through the programmed material by themselves at their own pace and after each step their comprehension is tested by answering test questions or filling in a diagram. Progression to the next step in the instructional sequence is solely dependent on whether the students satisfactorily pass the test, otherwise, that step is repeated (Ado & Abasi, 2021). Programmed learning strategy stems from the science of behaviorology. The science addresses the interactive relation between behaviour and the milieu in which it occurs. The typical educator assumes that if materials are well sequenced and well presented, the instructional job has been done, and that when a student fails to learn, then the instructional model holds the student at fault. Programmed instruction proposes just the opposite: If the student does not learn, then the instructional materials need to be revised. But more than reworking of the materials is involved.

Programmed learning addresses the controls over the teacher as well as those over the student. The instructional setting must be designed so that the teacher is also shaped to take the right actions. Programmed learning consists of the teacher coming under control of the interaction of student behaviour with specific features of the

instructional setting. The cybernature of programmed learning distinguishes it from other instructional technologies. The student interacts with materials designed by an instructional designer, and the student's success, or failure, at each step of the instructional process shapes the teacher's revision of materials or design of future ones. The design effort is guided by the framework of the science combined with the effects of prior engineering efforts. Programmed learning is believed to go a long way to help achieve the global aim of Mathematics and science education in general, which is to enable learners acquire knowledge, skills and attitudes that would be relevant to their future livelihoods.

Another issue that has continued to attract attention in educational research as a significant factor influencing students' learning outcomes, attitudes, and responses to different instructional strategies is gender. Gender could be seen as all range of physical, biological, mental and behavioural characteristics which are naturally embedded on individual and are used to make clarifications and distinctions between females and males (Aransi, 2019). It may be associated with being masculine or feminine, including the construction of identities, expectations, behaviours and power relationships derived from social interactions (Ambe-Uva, Iwuchukwu & Jibrin, 2018). Gender issues could be linked with students' academic performance in subjects since both males and females are assumed to differ and as such their academic performances might as well differ. Some studies have shown that there are distinguishing differences in the cognitive, affective, and psychomotor skill achievement of students with respect to gender (Olowe, 2015), whereas some others provided reports that there are no distinguishing differences in academic performance of students as a result of gender (Olaoye & Adu, 2015). In view of these contrasting reports, this study sought to investigate the effect of programmed instruction on students' comprehension of the concept of quadratic equations, considering gender as a moderator variable.

Statement of the Problem

Mathematics remains one of the most challenging subjects in the Nigerian secondary school curriculum, with persistent evidence of students' poor performance, particularly in algebraic concepts such as quadratic equations. Despite their importance in scientific reasoning and practical problem-solving, many students still find it difficult to comprehend the principles and applications of quadratic equations, resulting in low achievement and negative attitudes toward mathematics. Traditional teaching methods, often dominated by verbal explanations and teacher-centred delivery, have not effectively addressed these difficulties, as students continue to struggle with abstract reasoning and comprehension. In response to this, programmed instruction, being a learner-centred approach that presents content in a logical sequence with immediate feedback, has been advocated for improving understanding and motivation. However, its effectiveness in enhancing students' comprehension of quadratic equations remains insufficiently explored, particularly within Itu Local Government Area. Also, gender differences in learning outcomes continue to generate concern in mathematics education, raising the need to determine whether male and female students benefit equally from programmed instructional strategies. This study, therefore, sought to investigate the effect of programmed instruction on students' comprehension of quadratic equations in Itu Local Government Area, with gender as a moderating variable.

Purpose of the Study

The main purpose of this study was to investigate the effect of programmed instruction on students' comprehension of the concept of quadratic equations in Itu Local Government Area of Akwa Ibom State. In specific terms, the study sought to:

1. Compare students' comprehension of the concept of quadratic equations when taught using programmed instruction and conventionally.
2. Compare male and female students' comprehension of the concept of quadratic equations when taught using programmed instruction.

Research Questions

The following research questions were posed to give direction to the study:

1. What is the difference in the mean comprehension score of students taught the concept of quadratic equations using programmed instruction and conventional methods?

2. What is the difference in the mean comprehension score of male and female students taught the concept of quadratic equations using programmed instruction?

Hypotheses

The following null hypotheses were formulated to guide the study:

1. There is no significant difference in the mean comprehension score of students taught the concept of quadratic equations using programmed instruction and conventional methods.
2. There is no significant difference in the mean comprehension score of male and female students taught the concept of quadratic equations using programmed instruction.

METHOD

The study employed quasi-experimental non-equivalent group design. Area of study was Itu Local Government Area of Akwa Ibom State. The population of this study comprised all the public Senior Secondary two students in Itu Local Government Area for the 2024/2025 academic session numbering 2,728 from 8 schools. A sample size of 104 SS2 students was involved in the study. Random sampling technique was used to sample two public co-educational schools. Two intact classes were randomly sampled from each of the schools which were assigned to the experimental group and control group respectively. The two groups were exposed to pre-test and post-test respectively. The instrument for data collection was tagged Quadratic Equation Comprehension Test (QECT). The QECT consisted of 30 multiple choice questions which have four options A, B, C, and D, scored one mark each with a total of 30 marks. The test was developed by the researcher from the specified content “quadratic equations” and also from past questions using Table of specification. The objectives of the topics served as a guide in developing the questions. The QECT was validated and trial tested with the reliability index of 0.82 using Kuder-Richardson’s(KR-20) formula. After obtaining approval from the principals of the selected schools, the researcher first administered the pre-test to the students in the two schools and obtained their scores to ascertain their pre-entry ability before treatment. After the instructional process, post-test was administered to the students to assess their comprehension after treatment. On completion, the instruments were collected and appropriately parcelled for easy identification during scoring and collation.

RESULTS

The data generated from the retrieved instruments were analysed using mean and standard deviation to answer the research questions and independent t-test statistics to test the hypotheses at 0.05 level of significance.

Answering the Research Questions

Research question one: *What is the difference in the mean comprehension score of students taught the concept of quadratic equations using programmed instruction and conventional methods?*

Table 1: Mean and standard deviation of students’ pretest posttest comprehension scores on treatment

Methods	n	Pretest		Posttest		Mean Gain
		Mean	SD	Mean	SD	
Programmed Instruction	53	4.4	1.4	14.3	2.1	9.9
Conventional Method	51	3.8	1.4	10.1	1.7	6.3
Mean difference		0.6		4.2		3.6

Table 1 revealed that the mean gain comprehension scores (9.9) of students taught the concept of quadratic equations using programmed instruction is greater than the mean gain comprehension scores (6.3) of those taught using conventional teaching method with a mean difference of (3.6) between the two groups. This implies that students taught using programmed instruction benefited more and scored higher than those that were taught using conventional teaching method.

Research question two: *What is the difference in the mean comprehension score of male and female students taught the concept of quadratic equations using programmed instruction?*

Table 2: Mean and standard deviation of male and female students' pretest posttest comprehension scores on treatment

Methods	Gender	n	Pretest		Posttest		Mean Gain
			Mean	SD	Mean	SD	
	Male	23	3.5	1.1	14.2	2.3	10.7
Programmed Instruction							
	Female	30	4.0	1.6	14.5	1.9	10.5

As shown in Table 2, the mean gain comprehension scores (10.7) (10.5) of male and female students taught the concept of quadratic equations using programmed instruction is approximately equal. This implies that both male and female students that were exposed to the use of programmed instruction in teaching and learning quadratic equations benefitted equally thereby performing at the same pace. Programmed learning strategy has shown to be a gender friendly instructional strategy thus enhancing both male and female students' comprehension equally.

Testing the Hypotheses

Hypothesis one: *There is no significant difference in the mean comprehension score of students taught the concept of quadratic equations using programmed instruction and conventional methods.*

Table 3: Independent t-test result on students' mean comprehension scores in mathematics based on methods of teaching (N = 104)

Methods	N	Mean	SD	df	Sig.	p-cal.
Programmed Instruction	53	14.3	2.1			
				102	.05	.000 ^s
Conventional Method	51	10.1	1.7			

s = Significant at .05 level of significance

Analysis of independent t-test results in Table 3 revealed that there is a significant difference between the mean comprehension score of students in taught the concept of quadratic equations using programmed instruction and conventional method in favor of those taught using programmed instruction [$p\text{-cal} = .000 @ p < 0.05$]. The null hypothesis is therefore rejected. This implies that programmed instruction significantly enhanced students' comprehension of the concept of quadratic equations when compared with conventional teaching method. Thus, the mean difference earlier observed in Table 1 is statistically significant at .05 probability level.

Hypothesis two: *There is no significant difference in the mean comprehension score of male and female students taught the concept of quadratic equations using programmed instruction.*

Table 4: Independent t-test result on male and female students' mean comprehension scores in mathematics based on method of teaching (N = 53)

Method	Gender	N	Mean	SD	df	Sig.	p-cal.
	Male	23	13.6	3.2			
Programmed Instruction					51	.05	.963 ^{NS}
	Female	30	12.1	3.2			

NS = Not Significant at .05 level of significance

Analysis of t-test results as shown in Table 4 revealed that there is no significant difference between the mean comprehension scores of male and female students taught the concept of quadratic equations using programmed

instruction [$p\text{-cal} = .963 @ p < 0.05$]. The null hypothesis is therefore retained. This implies that there is no significant difference in the mean scores of male and female students' comprehension of concept of quadratic equations when taught using programmed instruction. Hence, both gender benefited from the methods of teaching.

DISCUSSION OF FINDINGS

The findings of this study in testing hypothesis one revealed a significant difference between the mean comprehension scores of students in taught the concept of quadratic equations using programmed instruction and those taught using conventional method of teaching. Hence, students taught using programmed instruction had higher comprehension scores than their counterparts taught using the conventional teaching method. This finding agrees with Ado and Abasi (2021) who found out in their study that students have higher interest and performance in mathematics when taught using programmed instruction than their counterparts when taught using conventional method of teaching. Also in support of this findings, Kurbanogbu, Taskesenligil and Sozbilir (2018) reported that students become overwhelmed and satisfied when programmed instruction is employed in teaching. The likely explanation for this outcome may be connected to the fact that programmed instruction helped the learners to possess a meaningful in-depth knowledge of the content area when compared to the conventional teaching method.

The findings of this study in testing hypothesis two revealed that there was no statistically significant difference between male and female students' comprehension of the concept of quadratic equations when taught using programmed instruction. This implies that, programmed instruction is superior to the conventional method irrespective of gender in fostering students' comprehension. This finding also agrees with Igwe and Okoye (2022) who found out in their study that there was no significant difference in the academic performance of male and female students taught science using programmed instructional method.

CONCLUSION

This study revealed that using programmed instruction in teaching and learning the concept of quadratic equation provides a better insight and deep comprehension for the students. The application of this method of teaching has enhanced students' comprehension in learning. It is also proved from the findings of this study that the use of programmed instruction is more effective in facilitating and improving male and female students' comprehension in mathematics than the conventional teaching method. By implication, this affirmed that students' comprehension in mathematical concepts depend on the method of instruction. Thus, programmed instruction is significantly a very useful instructional method for increased meaningful learning and higher comprehension for students regardless of their gender. It can be admitted that teachers' frequent use of this method will definitely enhance teaching output to a great extent.

RECOMMENDATIONS

Based on the findings of this study, the following recommendations are made:

1. Mathematics teachers should develop and use programmed instruction in teaching in senior secondary schools since it has proven to be a viable option in enhancing students' comprehension in mathematics and it is not gender-biased.
2. Ministry of Education and professional bodies such as Teacher Registration Council of Nigeria (TRCN) and Science Teachers Association of Nigeria (STAN) should organize conferences and workshops where the use programmed instruction will be exposed to teachers for better application and to meet up with the challenges and demands of the new curriculum.

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