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Assessing Teachers' Formative Evaluation Strategy as Related to Senior Secondary School Students' Achievement in Mathematics

Adeneye Olarewaju A. Awofala[1], Afolabi Oladayo Olaniyi[2]

[1]University of Lagos, Nigeria
[2]YABA College of Technology, Nigeria
Correspondence: E-mail: aawofala@unilag.edu.ng

ABSTRACT

The study investigated mathematics teachers' formative evaluation strategy as related to achievement in mathematics among 500 Nigerian senior secondary school students and 10 teachers from 10 senior secondary schools in Lagos using the quantitative research method within the blueprint of a pretest-posttest experimental research design. Treatment only contributed 4.4% to the prediction of achievement in mathematics of senior secondary school students. Gender alone contributed 1.2% to the prediction of achievement in mathematics of senior secondary school students. Based on this study, education planners at the secondary school level should develop a policy of education whereby a formative evaluation strategy should be officially recognized as a strategy to buffer students' achievement in mathematics at the secondary school level. Mathematics teachers in particular and teachers generally should adopt a continuous formative evaluation strategy that ensures that students are encouraged to learn and be themselves through the test–feedback cycle until they are confident in themselves to learn.

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1. INTRODUCTION

Teachers in every subject use formative assessment tool to check for understanding, monitor learning progress, provide appropriate feedback to students and inform instructional decisions as well as for lesson planning (Olagunju, 2015). Evaluation of students' mathematical work involves teachers' qualitative judgment of how well or how satisfactorily a student is performing or progressing in learning mathematics tasks (Ikpi *et al*., 2019). There are different types of instructional evaluation that a teacher can carry out. They include placement evaluation which is aimed at finding out students' entry behavior before beginning instruction; formative evaluation which provides ongoing feedback to teachers and students regarding successes and failures during instruction; diagnostic evaluation which attempts to find out specific learning difficulties that a student may have on specific mathematical facts, algorithms, concepts, principles or problem-solving. Evaluation is generally understood as testing which is a reliable procedure for collecting summative data, but it can also refer to the making of inferences based on students' performance in "authentic" learning activities, whether the inferences are for summative or formative purposes (Olagunju, 2015; Ikpi *et al*., 2019). Evaluation is a focal point in the teaching and learning process. Evaluation is generally perceived as testing which is a reliable way of collecting summative data and can be used as the measure of a student's academic performance either for formative or summative data purposes. According to Olagunju (2015), evaluation is the systematic assessment of the design, implementation, or results of an initiative for learning or decision-making. Evaluation can have a formative function that can help teachers to improve their teaching and learners improve their learning.

There are four types of evaluation as follows (Ajogbeje, 2012). Placement Evaluation is an evaluation of pupils' entry behavior in a sequence of instruction. This includes tests (pretests) constructed by classroom teachers to measure whether learners possess the prerequisite skill needed to succeed in their instruction. Diagnostic Evaluation: This type of evaluation is carried out most of the time as a follow-up evaluation to a formative evaluation. In other words, it is done after formative evaluation had been done. Formative Evaluation: This is the type of evaluation designed to help both the student and the teacher pinpoint areas where the student has failed to learn so that the failure may be rectified. Summative Evaluation: This is the type of evaluation carried out at the end of the course of instruction to determine the extent to which the objectives have been achieved. This research work considered the formative type of evaluation. Formative evaluation is highly effective in raising the level of student attainment, increasing equity of students' outcomes, and improving students' ability to learn. According to Ajogbeje *et al*. (2013), formative evaluation is a process used by teachers and students during instruction that provides feedback to adjust ongoing teaching and learning to improve students' achievement of the intended instructional outcomes. In addendum, formative evaluation is much more than repeated assessment measures over time. Formative evaluation has been highly touted for its purported positive impact on student learning (Olagunju, 2015).

Quantitative and qualitative research on formative evaluation has shown that it is perhaps one of the most used measures for promoting high performance, raising overall levels of student achievement, exposing learning deficiencies, increasing retention and transfer of learning, and motivating learners. Policymakers in the education sector, teachers, and researchers are in great support of formative evaluation due to its impact on and lubrication for teachers and learners in the teaching-learning process. The utilization of formative testing in the teaching-learning process involves checks and balances. According to Ikpi *et al*. (2019),

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formative evaluation for learning involves a continuous way of checks and balances during the teaching-learning process. This method allows teachers to check their learners' progress as well as the effectiveness of their practice, thus allowing for self-evaluation and evaluation of the students. Formative evaluation is a proactive evaluation design as a concept of feedback to both teachers and learners (Ozan & Kincal, 2018). During or after instruction in a classroom, the teacher needs active feedback to enable him to improve in his teaching and to eradicate short-fall. The students are at the receiving end if the teacher does not make use of the active feedback he gets from formative evaluation. The impact of formative evaluation arises from the strength of the feedback provided to students about their learning and to teachers about their teaching (Ndirika & Ubani, 2017; Olagunju, 2015).

Academic achievement is the student's level of attainment in the grade point average of courses offered in a particular session by a student (Awofala *et al*., 2022a). There is no general or special way in measuring academic performance; it can be through continuous assessment or examination. Evaluation carried out continuously is what is known or called continuous assessment. Continuous assessment is a formative evaluation approach specified systematically to find out the level of a learner's assimilation and recall of what the learner has learned. It may take different forms such as formal questions given during classroom teaching, take-home assignment, or project work. Academic achievement is an apparent occurrence in many developing countries like Nigeria. Thus, the academic achievement should not be viewed only in terms of final examinations by national examination bodies, but continuous assessment should be used to measure academic performance in other for students to get to the standard set by the national examination bodies. Students are the most essential assets for any educational institute.

The social and economic development of the country is directly linked with students' performance. The students' performance plays an important role in producing the best quality graduates who will become great leaders and manpower for the country thus responsible for the country's economic and social development (Awofala & Lawal, 2022). In contrast, Nigerian universities and other tertiary institutions have been labeled with negative and downgrading words for their products. In affirmation Okunuga *et al*. (2020), despite the whopping sums of funds being sunk in the educational sector, the standard of education could not be restored to what it used to be and it is unlikely that it would get anywhere close to what was obtained in the years of her glory. Mathematics is considered by many people, institutions, and employers of labor, among others, as very important. Mathematics in tertiary institutions can be studied in two ways, on the first part it can be studied as a course in another discipline, while on the other hand, it can be studied as a discipline. For this study, the students studying mathematics as a discipline will be our focus. Most students, who study mathematics as a course of discipline at a tertiary institution, chose to study mathematics out of their desire to develop their skills. Mathematics education according to Awofala and Anyikwa (2014) is the act of mastering numeracy in abstract and concrete terms.

Mathematics has the potential of applied to all branches of science; it can be likened to a nucleus in education. The development of all other branches of science is heavily dependent on mathematics (Awofala & Lawani, 2020). Mathematics is the science of abstract objects that relies on logic rather than on observation as it is a standard of truth yet employs observation. As mathematics is so important, mathematical behaviors also are at every level and in every field, from preschool education programs to higher education programs (Awofala & Sopekan, 2020). Mathematics is thus seen as the building block for all we do in our daily lives including mobile devices, architecture (ancient and modern), arts, money, engineering, and even sport. That is why most students need to devote most of their studying time to

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mathematics (Awofala *et al*., 2013; Oladipo *et al*., 2020). All these show the uniqueness of mathematics and explain why mathematics is given priority and the need to raise successful students in mathematics in preparation for adult life. Also, employers in the engineering, construction, pharmaceutical, finance, and retail sector have all expressed their continuing need for people with appropriate mathematical and scientific skills (Oladipo *et al*., 2020). Thus, mathematics culture can contribute to a disciplined and ordered pattern of life. With ample evidence to show, secondary school student's academic performance in mathematics has been variously reported by individuals and group of persons to be generally poor and the general performance of students in mathematics have been observed to be in a poor state (Awofala, 2017).

Many variables including affective and instructional variables may play important roles in students having positive or negative academic performance in mathematics (Awofala *et al*., 2022b; Awofala & Sopekan, 2020). Teachers' instructional strategies have been significant in this respect (Awofala & Lawani, 2020). This study was set to look into mathematics teachers' formative evaluation strategy as related to senior secondary school students' achievement in mathematics.

The following research questions guided the study:

(i) What is the effect of formative evaluation strategy on students' achievement in senior secondary school mathematics?

(ii) What is the influence of gender students' achievement in senior secondary school mathematics?

The hypotheses used are the following:

(i) H01: There is no significant main effect of treatment on mathematics achievement of senior secondary school students.

(ii) H02: There is no significant main influence of gender on the mathematics achievement of senior secondary school students.

(iii) H03: There is no significant interaction effect of treatment and gender on mathematics achievement of senior secondary school students.

2. METHODS

2.1. Research Design

This study used a quantitative research method within the blueprint of a pretest-posttest true experimental research design. The subjects were randomized. Experimental design is the process of carrying out research in an objective and controlled fashion so that precision is maximized and specific conclusions can be drawn regarding a hypothesis statement. Generally, the purpose is to establish the effect that a factor or independent variable has on a dependent variable.

2.2. Participants

Sampling design is that part of statistical practice concerned with the selection of a subset of individual observations within a population of individuals intended to yield some knowledge about the population of concern, especially to make predictions based on statistical inference. The study adopted a simple random sampling technique in selecting ten schools from the 50 senior secondary schools in education district VI of Lagos State, Nigeria. A simple random sampling technique was deployed in selecting fifty Senior Secondary School year one (SSS 1) students from each school, making a total of five hundred (500) respondents; one mathematics teacher from each school was selected randomly making ten (10) mathematics teachers selected from the education district VI. Five schools were randomly

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assigned as the experimental schools using a ballot while the remaining five schools were assigned as control schools.

2.3. Research instruments

One instrument tagged Mathematics Achievement Test (MAT) was used for data collection in the study. The MAT was used as a pretest and posttest. The post-test was a rearranged pretest to prevent the hallo effect which could result from over-familiarisation with the pretest. The MAT consisted of 50 multiple-choice questions options A to D. The test items were adopted from the past mathematics questions set for the Basic Education Certification Examination (BECE) in the years 2018-2022. Only questions set on number and numeration and algebraic processes were adopted for the study. Number and numeration and algebraic processes are often considered difficult by students at this level of education. The BECE is a standardized examination conducted for students at the end of their Junior Secondary School in Nigeria. The reliability coefficient of the MAT was carried out by administering the MAT twice on fifty senior secondary school mathematics students in year one that were not part of the main study and a test-retest reliability of 0.87 was computed using the Pearson correlation coefficient.

2.4. Procedure

The experimental and the control groups were pre-tested with MAT at the beginning of the school term. Participants in the experimental group were taught using an expository instructional method followed by questioning formative assessment strategy during instruction in number and numeration and algebraic processes. The strategy involved open-ended questions of the dialogic type. This was done by asking thought-provoking questions about the learning task and providing sufficient wait time for the students to generate responses for feedback and remediation. Thus, the experimental group was exposed to expository class teaching followed by a formative class test with feedback and remediation. The control group received only the expository classroom teaching. The training sessions for the experimental and control groups lasted for five weeks and each session lasted for 40 minutes twice a week. At the end of the training sessions, the same MAT was re-administered to both groups to determine the effect of the formative assessment strategy on the academic achievement of the experimental group.

2.5. Data analysis

The data collected through the pretest and the posttest were coded on the SPSS version 20 and were analyzed using the descriptive statistics of mean and standard deviation and inferential statistics of analysis of covariance (ANCOVA) at 0.05 level of significance.

3. RESULTS AND DISCUSSION

Table 1 shows that for the experimental group, the participants had a posttest mean score of 51.21 (SD = 12.41) and a pretest mean score of 37.69 (SD = 14.43). The mean difference in achievement between the pre-test and the posttest for the experimental group was 13.52 (standard error = 0.662). Also, for the control group, the participants had a posttest mean score of 50.88 (SD=8.92) and a pretest mean score of 32.68 (SD=9.68). The mean difference in achievement between the pre-test and the posttest for the control group was 18.20 (standard error = 0.785).

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Table 1. Descriptive statistics of formative evaluation strategy on mathematics achievement of senior secondary school students.

Treatment	Posttest			Pretest			Mean
	N	$\bar{x}$	S.D	N	$\bar{x}$	S.D	difference
Experimental	348	51.21	12.41	348	37.69	14.43	13.52 (0.662)
Control	149	50.88	8.92	149	32.68	9.04	18.20 (0.785)

Table 2 shows that the male group had a posttest mean score of 52.05 (SD = 11.37) and a pretest mean score of 35.81 (SD = 13.93). The mean difference in achievement between pre-test and posttest for male group was 16.24 (standard error = 0.694). Also, the female group had a posttest mean score of 49.88 (SD = 11.51) and pretest mean score of 36.69 (SD = 12.30). The mean difference in achievement between the pre-test and posttest for female group was 13.19 (standard error = 0.662).

Table 2. Descriptive statistics of gender on mathematics achievement of senior secondary school students.

Gender	Posttest			Pretest			Mean
	N	$\bar{x}$	S.D	N	$\bar{x}$	S.D	difference
Male	281	52.05	11.37	281	35.81	13.93	16.24 (0.694)
Female	216	49.88	11.51	216	36.69	12.30	13.19 (0.662)

Table 3 shows that there was a significant main effect of treatment on the mathematics achievement of senior secondary school students ($F(1,492) = 22.855$; $p < 0.05$). This implies that senior secondary school students who were exposed to formative evaluation strategy performed significantly better than those not exposed to the strategy. The effect size of the treatment obtained is 0.044 which implies that the treatment has only 4.4% effect on the mathematics achievement of senior secondary school students.

Table 3 shows that there is a significant main influence of gender on the mathematics achievement of senior secondary school students ($F(1,492) = 6.045$; $p<0.05$). The implication is that males performed better than females in mathematics achievement. The effect size of the gender obtained is 0.012 which implies that gender has only a 1.20% effect on the mathematics achievement of senior secondary school students.

Table 3. Univariate analysis of covariance of the main effect of treatment and gender on students' achievement in mathematics.

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Square
Intercept	236.371	1	236.371	2.450	0.118	0.005
Exam (Pre-test)	36850.936	1	36850.936	381.986	0.000	0.437
Treatment	2204.907	1	2204.907	22.855	0.000	0.044
Gender	583.154	1	583.154	6.045	0.014	0.012
Treatment×Gender	0.565	1	0.565	0.006	0.939	0.000
Error	47464.251	492	96.472			
Corrected Total	737892.000	497				

Table 3 shows that there was no significant interaction effect of treatment and gender on students' achievement in mathematics ($F(1,492) = 0.006$, $p>0.05$). Hence, the null hypothesis was not rejected. It was also seen that achievement in test pre-test) was a significant determinant of the variation in students' achievement in mathematics ($F(1,492) = 381.986$; $p<0.05$). It is seen that the effect of the treatment on mathematics achievement of senior

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secondary school students is about 4 times that of gender. However, the effect size of the interaction effect of treatment and gender obtained was 0.000 which implied that both variables had zero effect on the mathematics achievement of senior secondary school students. Thus, the treatment was not gender sensitive on achievement in mathematics among senior secondary school students.

The study found if the treatment (formative evaluation strategy) had any significant main effect on the mathematics achievement of senior secondary school students. In the experimental group, the mean posttest score was higher than the mean pretest score. The mean difference in achievement between the pretest and posttest showed that there was a significant difference in performance. The result of the study showed that there was a significant increase in the posttest score over the pretest score both for the control group and the experimental group but was more pronounced in the experimental group as against the control group. The increase in achievement of the experimental group over the control group at the posttest is an indication of the significant main effect of formative evaluation strategy on students' achievement in mathematics.

This result was in agreement with the findings of other researchers that formative evaluation influenced positively secondary school students' achievement in mathematics because they tend to score higher than those not exposed to the strategy and it tends to create an opportunity for learning by doing (Luvira *et al*., 2018; Ferdinal & Isramirawati, 2020; Dahal, 2019; Sahibzada & Himat, 2019; Orheruata & Oyakhirome, 2019). However, this study agreed with the conclusion of Ozan and Kıncal (2018) and Olagunju (2015) that there was a significant difference in the mean achievement score of mathematics students who are exposed and those not exposed to formative assessment. The feedback from this study should be provided to the schools concerned in line with who highlighted the necessity of feedback for formative evaluation strategy and Fitriana *et al*. (2018) who noted that feedback reinforces students' commitment to their learning thereby maintaining their achievement. Formative evaluation strategy was significant in improving students' achievement in mathematics simply because it helped in diagnosing students' learning difficulties in mathematics thereby helping to reduce their misconceptions in mathematics learning. The alternative remedial measures in the formative evaluation strategy helped to focus the attention of the students on mathematics learning.

The results of this study showed a significant main influence of gender on students' achievement in mathematics. The results disagreed with some researchers that gender is not a significant factor in students' performance or achievement in mathematics (Orheruata & Oyakhirome, 2019; Ndirika & Ubani, 2017; Olagunju, 2015) but agreed with some others that indicated a significant main influence of gender on students' achievement (Awofala, 2011; Awofala & Lawani, 2020; Ugwumaduka & Olabode, 2021; Ukoh & Onifade, 2020; Ajogbeje, 2012; Oribhabor, 2019). Thus, male students performed better in mathematics than their female counterparts. However, the study found a nonsignificant interaction effect of treatment and gender on senior secondary school students' achievement in mathematics. This result was in agreement with existing findings (Ugwumaduka & Olabode, 2021; Van den Berg *et al*., 2018; Ajogbeje *et al*., 2013) but ran contrary to other researchers' findings (Lawal & Awofala, 2019).

4. CONCLUSION

This study has shown that formative evaluation as a strategy has a significant effect on mathematics achievement in senior secondary school. Howbeit, its effect was found to be positive as it resulted in significantly higher achievement among the students. Also, gender

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was found to have a significant influence on the achievement in mathematics of senior secondary school students. In addition, mathematics achievement of male and female senior secondary school students when taught with formative evaluation strategy differed significantly. Lastly, the interaction effect of formative evaluation strategy and gender has no significant effect on achievement in mathematics of senior secondary school students. The outcomes of this study have shown that formative evaluation affects positively senior secondary school students' achievement in mathematics; it is therefore recommended as follows: Firstly, education planners at the secondary school level should develop a policy of education whereby formative evaluation strategy is officially recognized as a strategy to buffer students' achievement in mathematics at the secondary school level. Secondly, secondary school students should be encouraged to harness the benefits of formative evaluation by giving them continuous feedback on progress not only in mathematics but in other subjects. Also, mathematics teachers in particular, and teachers generally should adopt a continuous formative evaluation strategy that ensures that students are encouraged to learn and be themselves through the test–feedback cycle until they are confident in themselves to learn.

5. AUTHORS' NOTE

The authors declare that there is no conflict of interest regarding the publication of this article. Authors confirmed that the paper was free of plagiarism.

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