RELATIVE EFFECTIVENESS OF FORMATIVE EVALUATION STRATEGIES ON STUDENTS MATHEMATICS ACHIEVEMENT IN NIGEIAN SETTING

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Abstract

This study examined the relative effectiveness of formative evaluation strategies on students' Mathematics achievement among secondary school students in Ikom Education zone, in Cross River state, Nigeria. Quasi-experimental design using pre-test, treatment, post-test design with ANCOVA as post-hoc control was adopted for the study. Mathematics Achievement Test (MAT) with a test retest reliability coefficient of .70, was used to collect data from 160 secondary school two students (66 males and 94 females) drawn from 4 intact classes in 4 different public coeducational schools through a combination of purposive and random sampling techniques. Data analyses were done with Analysis of covariance (ANCOVA) with pre test as covariates. Key findings indicate that feedback/remediation group was the best in the teaching of mathematics followed by peer evaluation strategies and then self evaluation while the conventional method was least in bringing about high academic achievement from the students. Gender and Students' ability had no significant effect on students' academic achievement in mathematics. It was recommended that formative evaluation strategies should be adopted for teaching and learning of not just mathematics but other sciences and related subjects. Educational institutions vested with training of teachers should therefore retrain mathematics teachers with formative approaches.

Key words: Self-evaluation, Peer evaluation, Feedback/remediation, Formative Evaluation Strategies, Mathematics Achievement Test

Introduction

Learning outcomes in Mathematics in both primary and post-primary schools remain low in most sub Saharan African countries. In Nigeria, it is commonly observed that performance of students in this core subject is poor at the end of secondary school cycle as evident by The West Africa Examination Council Annual Reports (2005 – 2014). The poor performance in Mathematics has been associated with teacher dominated teaching and assessment approaches (Udousoro, 2000), low engagement with slow learners, and less time-on-task, culminating in inadequate opportunity to learn especially in poorly resourced

crowded classrooms. Consequently, learners may be progressing through the system without the relevant basic skills in problem solving, which is characterized by the subject.

Available literature on instructional and assessment strategies emphasize the need for having classrooms that are less teacher-scripted and less teacher command if learners are to co-construct knowledge and avoid knowledge growth stunting (Scot, Callahan & Urquhart, 2009; Reilly, Lilly, Bramwell & Kronish, 2011). Alternative methods and learning strategies, which effectively support performance-based and all round education are therefore being sought and promoted to address these challenges. The use of formative evaluation in a modern classroom is some of such pedagogies that are increasingly being promoted as tools for improving performance and quality (Ajogbeje, 2008). It is proven that when properly integrated, formative evaluation is the most powerful means to improve learning results in the teaching and learning process (Black & Williams, 2003). Teachers using formative assessment strategies and techniques are better prepared to meet diverse students' needs through differentiation and adaptation of teaching to raise levels of achievement and greater equity of students' outcomes.

Formative evaluation is an integral part of the teaching and learning process and its aim is to promote learning and to motivate learners. It is assessment for learning. Formative assessment is a strategy designed to identify learners' learning difficulties with a view of providing remediation measures to enhance the performance of majority of students. According to Gronlund and Linn (1990), formative assessment serves three uses namely: (i) to plan corrective action for overcoming learning deficiencies; (ii) to aid in motivating learners and (iii) to increase retention and transfer of learning. This means that students' responses to formative test could be analyzed to reveal group and individual errors needing correction.

Black and William (2003), provide some basic principles to support its use to include, the provision of effective feedback to students; the active involvement of students in their own learning; adjusting teaching to take account of the results of assessment; a recognition of the profound influence assessment has on the motivation and self-esteem of students, both of which are crucial influences on learning; the need for students to be able to assess themselves and understand how to improve.

Among the components of formative evaluation are self evaluation, peer assessment and feedback with remedial instructions. Self-assessment is more accurately defined as a process by which students (i) monitor and evaluate the quality of their thinking and behavior when learning and (ii) identify strategies

that improve their understanding and skills. Self-assessment occurs when students judge their own work to improve performance as they identify discrepancies between current and desired performance. When properly implemented, students self assessment can promote intrinsic motivation, internally control effort, a mastery goal orientation and more meaningful learning. In both classroom assessment and large- scale accountability assessment, it empowers students to guide their own learning and internalize the criteria for judging success (McMillan & Hearn, 2005).

Again peer assessment has the potential to affect individual achievement and help students evaluate their learning, learn how to work in groups and also learn from one another. More so, feedback given as part of formative assessment helps learners become aware of any gap that exist between their desired goal and current knowledge, understanding, or skills and guides them through actions necessary to obtain the goal (Sadler, 2005). The present study therefore seeks to investigate the relative effectiveness of formative evaluation on student's achievement in senior secondary schools mathematics in Ikom Education zone of Cross River State, with gender and ability levels as moderator variables.

Purpose of the study*:* This study examined the comparative effects of formative evaluation strategies (self evaluation, peer evaluation and feedback evaluation) on academic achievement of secondary school students in mathematics.

Null Hypotheses

1. There is no significant main effect of treatment on students' academic achievement in mathematics.
2. There is no significant main effect of gender on students' academic achievement in mathematics.
3. There is no significant main effect of ability level on student achievement in mathematics.
4. There is no significant interaction effect of treatment by gender on their mathematics achievement.
5. There is no significant interaction effect of treatment by student's ability level on their mathematics achievement.
6. There is no significant interaction effect of gender by ability level on mathematics achievement.
7. There is no significant interaction effect of treatment, gender by ability level on student's achievement in mathematics.

Methodology

Research design: The study adopted a pre- test, treatments, posttest quasi-experimental design, with ANCOVA as post-hoc control, in four intact groups. This quasi-experimental design was appropriate because of the administrative constraints that affected a fresh randomization of subjects into the four groups. A 4 x 2 x 3 matrix design was

adopted with instructional strategies at four levels self evaluation, peer evaluation, feedback and conventional method) being crossed with gender at two levels (male and female) and students ability at three levels (high, average, and low).

Subjects: Subjects that participated in the study were 160 senior secondary school two students (SS2) (66males and 94 females) selected from four schools through a combination of purposive random sampling techniques. Schools that participated in the study were those that : (a) must have presented candidates for SSCE in the past ten years; (b) must have at least two intact SS2 classes; and (c) the teachers are willing to serve as research assistance in the study.

Measures: A 30 item multiple choice Mathematics Achievement Test (MAT) was adapted for the study. The test was used for both pre-test and posttest. The instrument was design to measure students understanding in content areas like numbers and numeration, algebraic process, geometry, trigonometry, and statistics, based on second term scheme of work for 2014/2015 school year, with options (A, B, C & D). The students were required to tick the correct option.
In order to estimate reliability of the instruments, the draft version of the test was trial-tested twice on 68 students within a time interval of 14 days. A test retest reliability estimate of .70 was obtained as a measure of internal consistency reliability for the Achievement test.

Treatment Administration: Before the commencement of treatment, Mathematics teachers in the participating schools were trained on how to administer treatment to their respective groups. The four experimental groups were then pre-tested using 30- item MAT, which was also used to classify students into different ability levels of low, average and high. This was followed by instructions in four intact classes for 8 weeks. Experimental group 1, was exposed to self evaluation strategy. This strategy featured activities focused on reflections, brainstorming, laundry day, graphic organizers, individual white-board, and learning response logs. Experimental group 2, was exposed to self evaluation strategy, and featured activities focused on group discussion method, projects method, four corners, games, observations, collaborative group evaluation, think – pair-chair and practice presentations; while experimental group 3, exposed students to feedback and remediation. This group carried out such activities like self observation and reviews, peer evaluation and reviews, student assessment task and attainment of learning outcomes, learning/ response log, documentations, and observations. The fourth group however, was exposed to conventional approach. Students were instructed through teacher-directed lessons, notes on the board. Treatment lasted for eight weeks and was done simultaneously in all the schools involved in this study. An average of two periods of 45 minutes each totaling 1

hour, 30 minutes per week was utilized for instruct in each group. To ensure consistency in the teaching of the lessons, the research assistants used lessons plans that included all relevant instructional procedures needed for the lessons. One week after treatment, the test was re-administered to the four groups, as posttest.

Procedure for data analysis: Analysis of covariance ANCOVA was used to analyse the data. The pre-test scores were used as the covariate to remove extraneous variations from the dependent variables, increasing the precision of the measurement. The results are presented in Table 1 and 2.

Results:

Table 1: Summary of ANCOVA on post-test data in terms of treatment, gender and ability groups

Source of variance	Sum of squares	df	Mean square	F-ratio	p-level
Main effect (Combined)	7221.81	6	1203.635	17.972	.000
1. Treatment groups	17168.801	3	5722.934	85.452	.000
2. Ability levels	5350.525	2	2675.263	13.339	000
3. Gender	95.770	1	95.770	1.430	.234
2-way interaction	2331.885	11	211.990	2.843	.002
1. Treatment x ability	1905.032	6	317.505	4.741	.000
2. Treatment x gender	77.226	3	25.742	.384	.764
3. Gender x Ability	195.058	2	97.529	1.456	.237
3-way interaction					
Treatment x Gender x Ability	482.148	6	80.358	1.200	.310
Model	27788.163	23	1208.181	16.204	.000
Residual	10140.296	136	74.561		
Total	37928.496	159	238.544		

a. R Squared = .762 (Adjusted R Squared = .719)

Hypothesis 1

There is no significant main effect of treatment on students' academic achievement in mathematics. Table 1 shows that the main effect of treatment (self evaluation, peer evaluation, and feedback) has type III sum of squares for between group as 17168.801, 3 degrees of freedom, 5722.934 mean square, F ratio of 85.452 and a significance level of .000. This result shows that the computed F ratio of 85.452 is statistically significant at a chosen alpha level of .05. This result indicates that experimental and control group differs significantly from one another in academic achievement. Therefore, with the effect of the pretest covaried out and adjusted for, the null hypothesis of no significance effect is rejected. It is concluded that there is statistically significant mean difference among the four groups because F (3, 159) = 85.452, P < .05.

To show the direction of differences, Multiple Classification Analysis (MCA) was applied to the data (see table 2).

The result indicate that the adjusted mean score for experimental group 1, 2, 3, and control group 4 are 62.97, 66.45, 68.43 and 37.92 respectively. The result also show that, a beta value of .799 for main treatment effect was obtained, suggesting that treatment accounted for 79.9% of variance of scores on achievement in mathematics.

Table 2: Summary of MCA on post-test scores according to treatment, and ability group

Variables	Groups/Levels	N	Unadjusted mean	Adjusted mean	Eta	Beta
1.Treatment	Exp 1	40	63.15	62.97		
	Exp 2	40	66.47	66.45		
	Exp 3	40	68.47	68.43	.807	.799
	Control	40	37.67	37.92		
2. Gender	Male	66	60.27	60.40		
	Female	94	58.01	57.92	.072	.079
3.Ability	Low	50	51.48	57.93		

Average	21	57.52	60.62		
High	89	63.47	59.12	.350	.505

R =.813; (Adjusted R-square = .661)

Hypothesis 2

There is no significant main effect of gender on students' academic achievement in mathematics. Table 1 shows that there is no significant main effect of gender (F1, 159 = 1.430, p > .234) on achievement. This result indicates that male and female students do not differ significantly from one another in academic achievement. On the basis of this result, hypothesis 1 is upheld. Further analysis with multiple classification statistics (see table 2) indicates that the adjusted mean scores for male and female students are 60.40 and 57.92, respectively. The result also show that a beta value of .079 for main treatment was obtained, suggesting that treatment accounted for 0nly 7.90 percent of variance of scores on achievement.

Hypothesis 3

There is no significant main effect of ability level on secondary school students' academic achievement in mathematics. Table 1 shows that there is significant main effect of ability (F2, 159 = 13.339, p > .000) on achievement. This result indicates that low, average and high ability groups differ significantly from one another in academic achievement. On the basis of this result, hypothesis 2 is therefore rejected. To show the direction of difference, multiple classification analysis was applied to the data (see table 2). The result indicates that the adjusted mean scores for low, average and high ability groups are 57.93, 60.62 and 59.12, respectively. The result also show that a beta value of .606 for main treatment effect, was obtained, suggesting that treatment accounted for 60.6 percent of variance of scores on achievement.

Hypothesis 4

There is no significant interaction effect of treatment by gender on their mathematics achievement. Table 1 shows that there is no significant interaction effect of treatment and gender (F3, 159 = 0.384, p > .764) on achievement. On the basis of this result, hypothesis 4 is upheld.

Hypothesis 5

There is no significant interaction effect of treatment by student's ability level on their mathematics achievement. Table 1 shows that there is significant interaction effect of treatment and ability (F6, 159 = 4.741, p > .000) on achievement. On the basis of this result, hypothesis 5 is rejected.

Hypothesis 6

There is no significant interaction effect of gender by ability level on mathematics achievement. Table 1 shows that there is significant interaction effect of gender and ability (F3, 159 = 1.456, p > .237) on

achievement. On the basis of this result, hypothesis 6 is rejected.

Hypothesis 7

There is no significant interaction effect of treatment, gender by ability level on student's achievement in mathematics. Table 1 shows that there is no significant interaction effect of treatment, gender and ability ($F_{6, 159} = 1.200$, $p > .310$) on achievement. On the basis of this result, hypothesis 7 was retained.

Discussion

Main effect of treatment on students' academic achievement in mathematics**.**

The result relating to the main effect of treatment indicates that there is a significant main effect of treatment on student academic achievement. The result showed that students exposed to feedback/remediation (group 3) performed significantly higher than those exposed to self evaluation only and peer evaluation only. Again, students exposed to peer evaluation only (group 2) performed better than those exposed to self evaluation only (group 1) who in turn achieved higher than those taught with conventional method of instruction (see table 5) in their post test scores. This implied that the adoption of feedback and remediation strategies in the teaching and learning process was the most effective at helping student achieve highly in mathematics.

This result agrees with the findings of Umoru-Onuka & Oludipe (2004) who discovered that students taught with feedback and remediation performed significantly better compared to those taught with the traditional or conventional methods in their post-test scores. Onuka reported that students were found to have tremendously improved, when feedback, which is the application of evaluation for improvement, was applied. Although some researchers in this field of study like Spiller (2009) and Duncan (2007), in their study, discovered that, teachers often express frustration that student do not incorporate feedback advice into subsequent tasks, and only see feedback in isolation from other aspect of the teaching and learning process, and consider feedback to be primarily a teacher-owned endeavour. In this light, the researcher is of the opinion that, for teachers not to experience this frustration again, efforts should be made to design assessment in such a way that students can see the direct benefits of attending to feedback. Teachers should use feedback evaluation as a way of correcting any detected anomalies in students' performance rather than using it as final verdict. In this light, Nicol (2008) opined that, careful preparation before hand could help to prime the students about the nature of feedback and its role in the learning process. He advised that students need to be actively involved in learning what the criteria mean and in understanding the goals and purpose of feedback. Particularly helpful in this aspect, is to get students to be actively involved in the process of teaching and learning which has been proven to be

most useful to students learning. The finding also aligns with the report of Hattie & Kimberly (2007) on their study on the impact of feedback on students learning achievement that feedback has the potential to have a significant effect on students learning achievement. They further mentioned that, the most effective improvement in students learning takes place when students get information or feedback about task and how to do it more effectively; and is clearly related to the learning goals.

On peer evaluation, this finding agrees with the results of Epple, Newlon, & Romano (2002), whose works revealed that grouping students in classrooms by ability could likewise have a significant impact on student's achievement, depending on the magnitude of peer influence. This is because, according to Sadler (1998), peer assessment is uniquely valuable because students may accept from one another's criticism of their work which they would not take seriously if made by their teachers. He pointed out that, peer work is also valuable because the interchange will be in language that students themselves will naturally use and understand, and because students learn by taking the roles of teachers and examiners of others. The finding also confirms the report of Spiller (2007), who noted that 'students receiving feedback from their peers can get a wider range of ideas about their work to promote development and improvement. The finding also confirms the report of Falchikov (2007), who noted that, peer evaluation, aligns with the notion that an important part of the learning process is gradually understanding and articulating the values and standards of a community of practice. He further suggested that, learning involves active participation in a community of practice in which members of the community determine and structure their own practice, and construct identities in relation to their community. Van den Berg (2006) further confirmed this finding, when he concluded that, peer evaluation has a significant effect in supporting future learning.

On self evaluation strategies, the findings confirms the report of Schunk (2004) who identified self monitoring as a skill necessary for effective self assessment and involves focused attention to some aspect of behaviour or thinking. According to him, self monitoring students pay attention to what they are doing, often in relation to external standards. In this light, Rolheiser and Rose confirms that, students who are taught self evaluation skills are more likely to persist on difficult task, be more confident about their ability and take greater responsibility for their work. Furthermore, the result agrees with Sheppard (2001) who noted that, self assessment fosters students' ability to make connections themselves, provides mechanism to enhance learning in a meaningful, rather than rote manner and results in greater students' motivation and confidence. In this light, James & Jessica (2005) confirm that, self assessment is integral to a mastery goal

orientation, for it is a skill that enables students to know how well they are progressing in their knowledge and skills. With this results from hypothesis one, it can be concluded that, the combination of self evaluation, peer evaluation and feedback/ remediation has the potential of improving even the dullest students in their mathematics achievement.

Main effect of students' gender on mathematics achievement

The result in respect to main effect of gender on secondary school students' academic achievement revealed that there is no significant main effect of gender on students' academic achievement in mathematics. The findings of this study agrees with studies undertaken by Akinbobola (2004) and Henshaw (2006), Oladunni (1995) and Daramola (1992) that gender have no significant effect on the performance of physic students. However, other studies such as Eriba & Sesugh (2006), Virginia (2005), were not so affirmative, as they all reported significant differences between males and females performances in sciences and Mathematics. However, this result of non-significant difference of male and female students in mathematics is not surprising because the sample for the study were drawn from the same educational zone being Ikom. More so, the schools used for this study were coeducational signifying similar exposures to learning experiences of male and female students in sciences.

Main effect of pupils' ability on basic science achievement

The result relating to main effect of students' ability levels on mathematics achievement revealed a significant difference between students of different ability levels on mathematics achievement. This implied that students in the high ability levels achieved higher than those in the average ability level who in turn achieved higher than those in the low ability level in mathematics. Thus, it could be surmised that students with high Intelligence Quotient (IQ) performed better than those with average IQ. So, students with low IQ level had the least scores in mathematics. The findings of this study parallels the results from Tennessee Technological University (2009), Ominiyi (2004) that there is a significant difference between students of different ability levels and academic achievement.

Interaction effect of treatment and gender on mathematics achievement

Findings from this study showed that there was no significant difference in the academic achievement of male and female mathematics taught with formative evaluation strategies and conventional method of teaching. The findings from Ekarika (2014), tallied with the result of this study in respect of effect of treatment and gender on students transfer of learning. The findings apparently revealed a non significant difference in the transfer of learning between male and female

students. Tennessee Technological University (2009), Adamson (2008), Akinbobola (2004), all corroborated the findings of this study that method of teaching has no significant interaction effect on male and female academic achievement in science subjects.

Interaction effect of treatment and students ability levels on mathematics achievement

The result relating to the interaction effect of treatment and students' ability levels using formative evaluation strategy and conventional method of teaching indicated a significant difference across students' ability levels. This implied that students in high ability group were significantly better than the average ability group who were in turn better than the lower ability group with respect to academic achievement in mathematics. This implied that students in the different ability levels who were instructed with formative evaluation strategies performed better than those taught conventionally. Thus, the use of formative evaluation strategies affected students in the upper IQ, they achieved significantly better than those in the lower IQ with respect to overall achievement. Formative evaluation strategies influenced the performances of low achieving students in the same vein. The use of formative evaluation instruction had a positive effect on the low ability learners. It led to improvements in achievement levels of the low ability learners. Thus, it could be surmised that formative evaluation strategies proved more effective than conventional method of teaching in increasing achievement of students across different ability levels. Conclusions from Tennessee Technological University (2009), James & Awodi (1997), Schaefer (1996), and Ekarika (2014), all paralleled the submissions that teaching methods do have effects on students of high, average and low ability levels respectively.

Interaction effect of gender and students' ability on mathematics achievement

When considering the interaction of gender and students' ability levels, the findings of this study showed no significant interaction effect between gender and students' ability levels on academic achievement. In essence, the findings concluded that interaction of ability levels and gender did not play a significant role in students achievement but it was teaching strategies (the use formative evaluation strategies) itself that played the most significant role in enhancing students achievement in mathematics. Buttressing this finding, the study of Tennessee Technological University (2009), and Ekarika (2014) indicated no significant difference in the interaction of gender and ability levels on students' academic achievement.

Interaction effect of treatment, gender and students' ability on mathematics achievement

Analyzing the results of this study, with respect to interactive effect of treatment, gender and students' ability levels on mathematics academic achievement,

there was no significant interaction effect. In essence, the result concluded that ability levels and gender did not play a significant role as teaching strategies. Thus, it could be concluded that the adoption of formative evaluation strategies played the most significant role in enhancing students' academic achievement in mathematics. Thus, formative evaluation strategies proved to be a more effective teaching strategy than the conventional method of teaching. Tennessee Technological University (2009) mimicked the findings of this study along similar lines that interaction of teaching method, gender and students' ability level did not produce any significant difference in students' academic achievement but that teaching method interacting with students ability proved significant.

Understandably, gender in itself has little or insignificant effects on students academic achievement because each student whether male or female is considered to be intelligent in all the domains of formative evaluation though with variations depending on his or her strong or weak intelligences type. So, if lessons are presented in ways that all the areas (domains) of intelligences are captured, then each student whether male or female will have a fitting place and will excel in his or her area of dominant intelligences and even develop the weak intelligences. As such, no particular gender will have an edge over the other, as each student's potentials will have manifested itself in positive academic achievement.

Most of the findings agree with previous studies in other states in Nigeria and other countries with variances in educational standards, socio-economic, cultural backgrounds and value systems. As such, the findings cannot conclusively be applied to Ikom education zone, cross river state, Nigeria. It must be noted that some of the studies cited and reviewed were done in related subject areas and teaching methods and not mathematics and formative evaluation strategies per se. Thus, the findings and conclusions cannot be hastily and authoritatively generalized to mathematics.

Conclusion and Policy Implications

From the results, it could be concluded that formative evaluation strategies are more effective in improving students' academic achievement in mathematics than the conventional method. Feedback/remediation strategy alone proved to be more effective than other formative evaluation strategies. The Conventional method is not a very effective strategy and should be complimented with formative evaluation strategies.

Judging from this conclusion, formative evaluation strategies should be adopted for teaching and learning of not just mathematics but other science and related subjects. Educational institutions

vested with training of teachers should retrain mathematics teachers on how to implement formative evaluation approaches into the classrooms. Curriculum developers and implementers should appraise and review the curriculum with the intent of incorporating formative evaluation approaches

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