Relative Effectiveness of Formative Assessment Techniques on Students' Academic Achievement in Mathematics Classroom Teaching and Learning

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Abstract: This mathematics classroom based experimental study determined the relative effectiveness of formative assessment techniques on students' academic achievement in Mathematics. Factorial research design was adopted for the study involving 100 students from 2 co-educational secondary schools drawn through multistage sampling procedure. Mathematics Achievement Test was the instrument used for data collection. The reliability of the instrument was established using Kudder Richardson (KR_{20}) formula and a reliability coefficient of 0.92 was obtained. Descriptive statistics of mean and standard deviation were used to answer the research questions and Analysis of Covariance (ANCOVA) was employed to test the hypotheses at 0.05 level of significance. The findings of the study revealed that the muddiest point formative assessment technique proved to be more effective in improving students' academic achievement in Mathematics than the think-pair-share technique. The findings also showed that the mean achievement scores of male and female students in Mathematics are not statistically significant. The muddiest point technique should be employed regularly by teachers for classroom assessment of the students since it is more effective in improving students' academic achievement in Mathematics.

Keywords: Classroom teaching & learning, formative assessment, think-pair-share, muddiest point, mathematics education, relative effectiveness

INTRODUCTION

Mathematics plays an important role in the growth, development and sustenance of a nation. Jayanthi (2019) observed Mathematics as the bedrock for nation building; it determines the level of science and technological components and development of any nation, which is a prerequisite for its development. Mathematics education is an essential component of secondary school since it provides students with the basic knowledge required for success in higher education and a variety of jobs (Mario de la & Helen, 2023). Consequently, Mathematics is one of the compulsory subjects offered by all students in secondary schools (Olasen & Lawal, 2020). Mohd (2016) pointed out that Mathematics has always been given extraordinary consideration in school because the nature of the subject is deep rooted in many other fields and disciplines. It as the foundation of all subjects thereby making the teaching and learning of Mathematics inevitable

(Faluyi, 2016). Despite the relevance of Mathematics due to its importance in the development of a country both on national, educational, social and individual level, the records of students' academic achievement in Mathematics over the years is still unsatisfactory.

Academic achievement refers to the results of an individual's performance that show how far he or she has progressed toward a given objective. The breakeven point of academic growth is referred to as academic achievement (Samuel & Ramon, 2020). Kpolovie, et al, (2014) viewed academic achievement to comprise students' ability and performance that linked to human growth, cognitive, emotional, and socio-physical development. Academic achievement, according to Onukwufor and Ugwu (2017), is defined as a score that shows a learner's level of success following teaching and learning. It's a way of demonstrating whether or not learning has occurred, as well as how much learning has occurred. Therefore, the performance of students in terms of grade or score in a Mathematics test or examination can be characterized as students' academic achievement in Mathematics. However, students' academic achievement in Mathematics over the years has been unsatisfactory. In Nigeria, especially at the secondary school educational level, one of the crucial problems faced is the students' unsatisfactory achievement in Mathematics (Sulieman & Hammed, 2019). Moyosore (2015) associates the unsatisfactory students' academic achievement in Mathematics to factors such as attitudes, interest, instructional strategy, classroom environment, and nature of assessment employed in the classroom. The author stressed that among this factor, the nature of assessment practices in the classroom appeared to be the most crucial as less attention have been paid to formative assessment techniques. These records of students' unsatisfactory achievement in Mathematics can be seen from public examination like West African Senior School Certificate Examination (WASSCE) conducted by West African Examination Council (WAEC). Owan (2020) analyzed students' achievement at credit level in Mathematics in May/June WASSCE from 2009 to 2018 and discovered that students' achievement at credit level was below average (50%). This implies that the percentage of students who obtain at least credit pass in Mathematics is below 50%.

The issue of these inconsistent and unsatisfactory students' achievement in Mathematics is also evident in the West African Examination Council (WAEC) Chief Examiner's report of 2016, 2017, 2018, and 2019. From the report it can be deduced that students have some misconceptions in some topics and found most topics difficult. The report also showed that students exhibit consistent weaknesses in most topics that contribute major questions in West African Senior School Certificate Examination (WASSCE) in Mathematics. Topics such as approximation and rounding up of numbers, graph drawing and reading from it, and statistics (measures of dispersion) that have been stated more than twice from 2016 to 2019 by the Chief Examiner, are topics that contribute considerable number of questions in WASSCE in Mathematics.

LITERATURE REVIEW

Formative assessment is an ongoing assessment. According to Adejor and Obinne (2013), it takes place while teaching and learning are still running. The purpose is to find out whether after a learning experience, students are able to do what they were unable to do previously. Formative assessment is defined as a type of assessment that is used to provide immediate feedback to the teachers in order to plan remedial action before the completion of the course or program (Nworgu, 2019). Therefore, formative assessment is a progress checking tool during instruction. According to Ugodulunwa and Uzoamaka (2015), the implementation of quality assessment techniques and the subsequent use of the information obtained from these assessments to enhance teaching and learning instructions are the two most important conditions for successful formative assessment.

Formative assessment provides immediate feedback to teacher and students during assessment. Spector et al. (2017) stressed that actual point or grade, short conferences to measure student progress and provide assistance or peer discussion and peer review are all ways in which feedback can take place. Written feedback from the teacher on assignments, identifying successes and areas of concern, is another typical kind of feedback. According to Clark (2012), feedback should instill confidence in students, particularly when it comes to problem-solving ability. Ajogbeje (2012) stated that formative assessment serves three purposes: planning corrective action for overcoming learning inadequacies, motivating learners and increasing learning retention and transfer. Ajogbeje further posited that the feedback from students' responses to a formative assessment may be analyzed to determine groups and individual faults that need to be corrected.

Formative assessment is useful to both students and teachers. Ojugo (2013) posited that formative assessment is beneficial to both students (for diagnosing learning difficulties and prescribing alternative remedial measures) and teachers (for locating specific difficulties that students are experiencing within subject matter content and forecasting the appropriate techniques to help the students understand the difficulties in the contents in order to facilitate improvement). Formative assessments in the classroom provide timely feedback on the learning process to both the teacher and the learners. Formative feedback shows the gap between what a student already understands and what the teacher expects from that knowledge and understanding (Afemikhe, 2018). Even more impressively, formative assessment closes the achievement gap by assisting the lower achievers (Black, 2012). However, it is argued that formative assessment techniques are missing or lacking from many classrooms for students' assessment (Black & Wiliams, 1998; Keeley, 2018). As a result, much still needs to be done by using formative assessment techniques in assessing students in classrooms in order to prepare them for the task ahead; educationally or career wise or both. The think-pair-share technique blends communication and thinking. This was introduced when science educators sought for a way to shift assessment from teacher centered to student centered (Eze & Obiekwe, 2018). The researchers further stressed that think-pair-share as a formative technique engross self-reflection, collaboration and multiple interactions (teacher to students, students to students, students to teacher) between students and teachers. According to Ifamuyiwa and Onakayo (2013), the think-pair-share is in three stages (think, pair and share) that begin when students are given an open-ended item to consider and are given time to think and, if necessary, scribble down their responses. After which, the students are then assigned (pair) to partner(s) with whom they will discuss and clarify their thoughts. Students are encouraged to present (share) their thoughts to the class or larger group. By going through this process, students are able to solidify and refine their thinking before having to share their answers with the whole class (Alison, 2011). This allows the teacher to spot any flaws in their thinking and rectify them on the spot. The think-pair-share technique is an excellent way to assess students' understanding levels (Bamiro, 2015). This is because the teacher moves round the class as students are sharing their thoughts and ideas to assess the overall depth of understanding.

The think-pair-share technique has been argued by researchers to have contributed to students' improvement and their academic achievement over the years. Eze and Obiekwe (2018) found the technique to be of immense contribution to students' achievement in Chemistry. This is in line with Nwaubani, et al. (2016) who found that think-pair-share significantly improve students' achievement in Economics. Furthermore, a study by Bamiro (2015) found that the think-pair-share's contribution to students' achievement is unmatched compared to the other techniques. For the sole reason that students tend to forget what they learn easily, as well as having troubles recalling information from memory in Mathematics over a period of time, this called for an assessment technique that might enhance their retention capacity and as

well might reduce the cognitive load on the working memory. The think-pair-share technique might be suited for that purpose. This is because the think-pair-share technique might be suitable for schema (the way the brain stores information in the long-term memory) development for easy remembering. This is because it involves three vital stages (think, pair and share) that might be crucial in schema development for long term information storage in the long-term memory.

As a result, it was used in this study because it might reduce the cognitive load on the working memory of students, and probably ensure the development of a schema which might in turn enhance students' retention capacity in Mathematics. More so, there was a need to make sure that students develop this schema during assessment in Mathematics lesson by pinpointing and planning remedial instructional objectives for the areas they still find difficult in the lesson, this necessitated the need for the muddiest point formative assessment technique.

Muddiest point formative assessment technique is a technique in which students are asked during or at the end of a lesson to jot down the section of the lesson that they are most confused about. This allows learners to reflect on their own learning and what they find difficult or simple to comprehend. The core benefit of this technique is that it provides students who are reluctant to speak out with an opening to let their difficulties known in an easy way (Alison, 2011). Index-card size pieces of paper are provided for use for this assessment procedure. The students are asked to describe the part of the lesson that they find the most difficult to understand. Saleem, et al. (2021) stressed that asking students to identify which part of the lesson they least understood or most difficult is a fascinating tale and potentially powerful integrative exercise. This is because it first calls for students to reflect on their understanding across several parts of the lesson to identify gaps and secondly, to contemplate, if only briefly, why or which one particular part of the lesson should be selected as the least understood. Their written replies on the piece of papers are collected for review by the teacher (King, 2011). The responses gathered enable the teacher to identify areas where the students might be struggling, which can be addressed immediately or in the next lesson.

The muddiest point formative assessment technique has been argued by researchers to play a significant part in students' improvement. In a study conducted by King (2011), the result showed that students' achievement in Chemistry improved immensely when assessed using muddiest point technique. This is in line with the findings of Akhtar and Saeed (2020) who found that the mean achievement scores of students assessed with the muddiest point technique was greater compared to other techniques. Also, a research study by Carberry, et al. (2013) on unmuddying course content using muddiest point reflection, proved to have positive impact on students' interest and achievement. More so, the technique might be of immense importance because it tends to elicit responses from all ability groups, more especially the low ability group without them having the fear of being laughed at.

The muddiest point technique was used in this study to assess students in Mathematics because it appeared that it doesn't discriminate among the ability levels (high, medium and low) as it tends to provide an opportunity for 100% engagement for all the groups. More so, the technique might tend to pin-point areas of misconception and difficulty in a lesson as well as identifying gap in students' understanding. By asking students to identify areas they are yet to understand might help reduce the cognitive load on their working memory. Since Mathematics has been perceived by students as a difficult subject over the years, it is crucial to use a technique that might pin-point areas they still find difficult in a lesson, so as to provide remedial instructional objectives immediately. Possibly, the most suitable technique for that is the muddiest point formative assessment technique, thus it was employed in this study.

Gender is a social construct that defines male and female identities. According to Ezeh (2013), gender is described as relative power, influence, roles and expectation (feminity and masculinity) that society ascribes to the two sexes on a differential basis. Therefore, gender was seen as any distinguishing feature, or characteristics that separate males from females in the society. The influence of gender on students' achievement and retention in science in general and Mathematics in particular, has been a global concern for science educators and researchers over the years. Consequently, there is no agreement among researchers on the outcomes of studies on gender influence. Where some researchers found a significant difference in students' academic achievement and retention in favour of males (Augustinah & Bolajoko, 2014; Allahnana, et al., 2018), others found in favour of females (Owodunni & Ogundola, 2013; Kwame, et al., 2015; Amalu, 2017). Also, studies have shown no significant difference in Mathematics achievement scores of male and female students (Oluwatayo & James, 2011; Ajai & Imoko, 2015). Moyosore (2015) concluded that when students are constantly introduced to formative assessment, there is no gender influences on their academic achievement.

Evidence abounds in literature of the unsatisfactory senior secondary school students' academic achievement and gender disparity in WASSCE in Mathematics. Among the many factors identified to be responsible for this ugly state of affairs; the most crucial has been the nature of assessment practices by teachers. As it appears that the nature of assessment practices by most teachers in nearly all the public secondary schools in Nigeria appears to be summative assessment. Summative assessment is a teacher centered assessment and as a result, might not give the students the opportunity to participate in the assessment process, interactive learning, self-reflection, identifying gaps in understanding (areas of difficulties and misconceptions), assessing one another nor inculcating the spirit of cooperative learning in tackling problems. The purpose of this study was to determine the relative effectiveness of formative assessment techniques on students' academic achievement in senior secondary Mathematics. The following questions were addressed;

1. What are the mean achievement scores of students taught and assessed in Mathematics using think-pair-share and muddiest point formative assessment techniques?
2. What are the mean achievement scores of students taught and assessed in Mathematics based on gender?

Hypotheses

The null hypotheses formulated were tested at $P<0.05$, level of significance:

$\mathbf{H0_1}$: there is no significant difference in the mean achievement scores of students taught and assessed using think-pair-share and muddiest point formative assessment techniques.

$\mathbf{H0_2}$**:** there is no significant difference in the mean achievement scores of male and female students taught and assessed in Mathematics.

RESEARCH METHODOLOGY

Design and Participants

The researchers adopted factorial research design. Particularly, the 2x2 factorial research design. According to Cheng (2016), a factorial research design is a type of design whereby the investigator manipulates two or more independent variables at the same time in order to investigate the independent effects of each variable on the dependent variables, as well as the effect caused by interactions among the variables. The

design also enables the researchers to investigate the interactions of independent variables with one or more other variables, at times known as moderator variable(s). This study used 2x2 factorial research design because it had two treatment groups (think-pair-share and muddiest point) and a moderator variable (gender) with two levels (male and female). Furthermore, the students were not randomly assigned to classes by the researchers, implying that there might be some relevant confounding variables that the researchers were unable to control. This study used intact classes that were randomly assigned to the experimental groups (two treatment groups). The study participants comprised of 100 senior secondary two (SS2) students from two intact classes using multistage sampling procedure. The treatment group for the think-pair-share technique comprised of 26 males and 22 females whereas the muddiest point comprised of 20 male and 32 female students.

Research Instrument

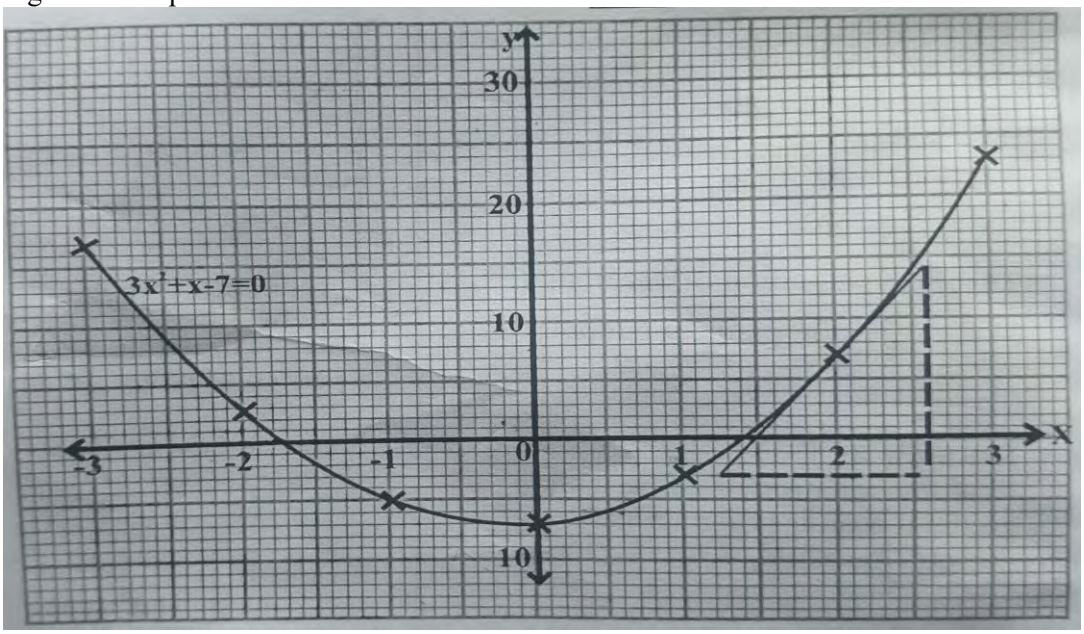
Mathematics Achievement Test (MAT) developed by the researchers was used for data collection. The instrument was 50 multiple-choice items with options A-D. The MAT is divided into two sections: A and B. Section A features demographic data of the respondents, whereas Section B contained information on the mathematics achievement test items. In the instrument, correct and incorrect responses attract one (1) mark and zero (0) mark respectively. Also, the highest possible score is 50 and the lowest possible score is 0. The scoring guide for the instrument was equally developed. The MAT's items were subjected to both face and content validation. The content validation was done using table of specification to determine the instrument's validity. Items were formed from three SS2 Mathematics topics based on the respective emphases placed on each of the topics in SS2 Mathematics curriculum as shown in the table of specification on Table 1. The MAT's items measure only objectives in the cognitive domain employing the revised Bloom taxonomy of educational measures. Approximations with 16 items; Gradient of a curve with 18 items and Measures of dispersion with 16 items were the topics which accounted for the 50 items in MAT. Three specialists face validated the instrument. The specialists performed a face validation of the instrument with respect to clarity of the items, suitability and effectiveness of the items for the study. Their corrections and modification on phrasing of the items, language level and the objectives led to the final production of MAT. The MAT sample is shown in figure 1.

Table 1. Table of specification for mathematics achievement test

COGNITIVE LEVELS	REM. 14%	UND. 30%	APP. 26%	ANA. 18%	EVA. 6%	CRE. 6%	Total 100%
CONTENT AREAS							
Approximations 32%	2(1&2)	5(3,4,5,6&7)	4(8,9,10&11)	3(12,13&4)	1(15)	1(16)	16
Gradient of a curve 36%	3(17,18& 19)	5(20,21,22,23&24)	5(25,26,27,28&29)	3(30,31&2)	1(33)	1(34)	18
Measures of dispersion 32%	2(35&36)	5(37,38,39,40&41)	4(42,43,44&45)	3(46,47&8)	1(49)	1(50)	16
Total (100%)	7	15	13	9	3	3	50

From the graph, determine the roots for the equation y=$3x^2$ + x -7.

Figure 1: Sample of the Mathematics Achievement Test



Reliability of the Instrument

Thirty-five copies of the instrument were administered to SS2 students that are not part of the area under investigation but has similar features to the area under study in order to ensure the instrument's reliability. The results of the administered instrument were recorded and subjected to Kuder-Richardson formula 20 (KR_{20}) in order to obtain the reliability index. The reliability index was found to be 0.92. The Kuder-Richardson formula 20(K_R_{20}) was used because it is a measure of internal consistency reliability for measures with dichotomous choices

Classroom Teaching Procedure

On the basis of assignment, two intact classes from two schools were randomly assigned into treatment groups (think-pair-share and muddiest point). One of the schools was used for think-pair-share treatment group and the other was used for muddiest point treatment group. For the sake of clarity, the schools were labeled. School for the think-pair-share treatment was named T while the school for the muddiest point treatment was named M. This was done to allow the researchers to have more control over the interactive effect. The experiment lasted for five weeks. The first week was dedicated to research assistant training and pretest. The research assistants administered the instrument as a pretest at the end of the training. For three weeks, the three-week lesson planned were covered during which students were taught and assessed using the assessment for learning technique allocated to each school. Students were assessed in first topic in the lesson plan (approximations) by research assistants in each school (T, M) using the assessment technique assigned to each school during the second week. The second topic (gradient of a curve) also followed that sequence in the third week, and the third topic (measures of dispersion) equally followed that pattern in the fourth week of the experiment. During each task in the classroom, the research assistant in the think-pair-share treatment school (T) guided students on how they could assess and share knowledge with peers, provide feedbacks to peers and coming to a consensus before sharing their ideas with the entire class. Also, the research assistant in the muddiest point treatment school (M) guided the students on how to reflect and

assess their own understanding in order to identify gaps in learning, guide the students on how to write muddiest points by using precise and concise phrases. More so, providing feedback, students assessed the feedback received and finally enhanced their own work. The teacher guides the students on weekly classes conclude lesson by going through the core points of the lesson, such as approximating numbers to ten, hundred, thousand, million, billion, and trillion.

Figure 2: Teacher sharing the lessons learned during the week

Think Pair Share:

Teacher's Activities

The teacher guides the students through the solution using the logarithm table and calculator and makes a comparison of the results obtained from both approaches. The teacher observes, provides feedback, and reinforces their answers.

Students' Activities

Students think individually and pair with peers, forming 3 groups. Students make use of the logarithm table to solve log2468. Students are expected to carry out the task with their peers as follows: Using the table, the characteristics are 3. To get the mantissa, check "24" under "6" difference "8" which is to yield 3923 = 3.3923. The students are to equally compare the calculator value with the table value to see if they yield the same results. A representative from each group shares their answers with the entire class. The students still in the group solve more problems and equally employ the calculator to make a comparison of the results obtained.

Figure 3. Think Pair Share

Muddiest Point:

Teacher's activities

The teacher guides the students through the solution of log2468 using the logarithm table and calculator and makes a comparison of the results obtained from both approaches.

Students' Activities

Students are expected to solve log2468 using a table, calculator and compare the results as follows: Using table, the characteristics is 3, to get the mantissa, check "24" under "6" difference "8" which yielded 3923 = 3.3923, Also, students are expected to punch log2468 and compare the value obtained with the table. The students are to solve more problems and equally employ the calculator to make a comparison of the results obtained. The students use 2 minutes to think individually in order to identify areas of difficulty or misconceptions, and after that, they write it down on the index card part of the lesson they still find difficult and hand it in to the teacher. The students use the feedback from the teacher and enhance their understanding, thereby clearing up the areas of misconception and difficulties.

Figure 4. Muddiest Point

The instrument that was administered to the students as a pretest was reshuffled and administered as a post-test to the two schools (T, M) two days after completing the teaching and learning (lessons), which was the fifth week of the experiment. The research assistants scored the scripts using the marking guide.

Method of Data Analysis

Descriptive statistics of mean and standard deviation were used to answer research questions and analysis of covariance (ANCOVA) was used to test the hypotheses at 0.05 level of significance. The ANCOVA was employed because it adjusts post-test scores using the pretest score to resolve variances in post-test scores that might have arisen from non-equivalence. If found that the probability value (p-value) is more than 0.05, the null hypothesis was not rejected. Otherwise, the null hypothesis was rejected. Glimpses of the experimental classes:

Figure 5. Experimental classes

Ethical Approval and Consent to Participate

The ethics committee at the school where the research was conducted granted ethical approval. Before the commencement of the study, the students were presented with informed consent forms to fill and sign. The informed consent forms were properly filled and signed. This research was carried out in accordance with the principles outlined in the ethical policy. The data collection from the entire sample was in accordance with the ethical standards of the researchers' institutional research committee and with the 1964 Helsinki declaration.

RESULTS

Result on Table 2 shows the pretest and post-test mean achievement scores of students taught and assessed in Mathematics using different forms of formative assessment technique. The result shows that the students who were taught and assessed using think-pair-share assessment technique had a pretest achievement mean score of 17.46; with a standard deviation score of 4.66 and a post-test achievement mean score of 30.50; with standard deviation score of 1.74. The mean gain score was 13.04. The result also shows that the group taught and assessed in Mathematics using muddiest point assessment technique had a pretest mean achievement score of 17.00, with standard deviation score of 4.30 and a post-test achievement mean score of 37.37, with standard deviation score of 2.71. The mean gain score was 20.37. The results of the study show that the students taught and assessed in Mathematics using muddiest point assessment technique achieved better than those assessed in Mathematics using think-pair-share technique. This result therefore shows that muddiest point assessment technique proved to be more effective.

Table 2. Scores of Students Taught and Assessed using Formative Assessment Techniques.

Assessment Techniques	Pre-test	Post-test

	N	$\bar{x}$	SD	$\bar{x}$	SD	Mean Gain
Think-pair-share Assessment	48	17.46	4.66	30.50	1.74	13.04
Muddiest Point Assessment	52	17.00	4.30	37.37	2.71	20.37

The result in Table 3 shows the ANCOVA result of the significant difference in the mean achievement scores of students taught and assessed in Mathematics using formative assessment techniques. Result shows that an F-ratio of $F(1, 95) = 216.095$, $p<0.05$, $\eta^2_p = 0.695$ was obtained. There is significant difference in the mean achievement scores of students taught and assessed in Mathematics using formative assessment techniques with those taught and assessed using muddiest point assessment technique having a higher mean gain. The result of the study further shows that the effect size, as indicated by the corresponding partial eta squared value of 0.695 shows how much of the variance in the dependent variable that is explained by the independent variable. The partial eta square of 0.695 which translate to 69.5% implies that 69.5% of the variance in students' achievement in Mathematics is accounted for by the forms of formative assessment.

Table 3. Effectiveness of Formative Assessment Techniques on Students' Achievement in Mathematics.

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	1190.340[a]	4	297.585	56.297	.000	.703
Intercept	6531.379	1	6531.379	1235.599	.000	.929
PRETEST	13.371	1	13.371	2.530	.115	.026
GROUP	1142.280	1	1142.280	216.095	.000	.695
GENDER	.676	1	.676	.128	.721	.001
GROUP * GENDER	.010	1	.010	.002	.965	.000
Error	502.170	95	5.286			
Total	117769.000	100				
Corrected Total	1692.510	99				

Result on Table 4 shows the mean achievement scores of male and female students taught and assessed in Mathematics. The result shows that the male student had a pretest achievement mean score of 17.46, with a standard deviation of 5.08 and a post-test achievement mean score of 33.41, with a standard deviation of 4.25. The mean gain score was 15.95. The result also shows that the female students had a pretest achievement mean score of 17.02, with a standard deviation of 3.90 and a post-test achievement mean score of 34.63, with a standard deviation of 3.99. The mean gain score was 17.61. Mean gain score of 15.95 and 17.61 for male and female students respectively imply that the female students achieved slightly better than the male students.

Table 4. Achievement Scores of Male and Female Students in Mathematics

Variable		Pretest		Post-test		
Gender	N	$\bar{x}$	SD	$\bar{x}$	SD	Mean Gain
Male	46	17.46	5.08	33.41	4.25	15.95
Female	52	17.02	3.90	34.63	3.99	17.61

The result in Table 3 shows the ANCOVA result of the influence of gender on students' achievement in Mathematics. The result shows that an F-ratio of $F(1, 95) = 0.128$, $p>0.05$, $\eta^2_p = 0.01$ was obtained. The associated probability value of 0.72 is greater than 0.05 set as level of significance. The mean achievement scores of male and female students in Mathematics is not statistically significant. This implies that gender is not a significant factor in determining students' achievement in Mathematics. The result of the study further shows that the effect size, as indicated by the corresponding partial eta squared value of 0.01 shows how much of the variance in the students' achievement in Mathematics that is influenced by gender. The partial eta square value of 0.01 which translate to 1.0% implies that 1.0% of the variance in students' achievement in Mathematics is influenced by gender. This result shows that gender does not significantly influence students' achievement in Mathematics when taught and assessed using different forms of formative assessment.

DISCUSSION

The result showed that muddiest point assessment technique improved students' achievement better than think-pair-share assessment technique. This result therefore shows that muddiest point assessment proved to be more effective. However, the standard deviation score of the think-pair-share assessment technique shows more homogeneous responses from the students than the muddiest point assessment technique. The finding further revealed significant difference in the mean achievement scores of students taught mathematics and assessed using formative assessment techniques with those taught and assessed using muddiest point assessment having a higher mean gain. There is no doubt therefore that the muddiest point assessment technique is more effective. The finding of the study agrees with King (2011), who conducted a study by using clickers to identify students' muddiest point in Chemistry and the result showed that students' achievement in Chemistry improved immensely. The study is also consistent with Akhtar and Saeed (2020a) who carried out a study on the effect of frayer model, choral response and muddiest point on students' academic achievement and found that muddiest point assessment technique enhanced students' achievement more than the other two assessment techniques. The result of the study also reinforces the earlier claims made by Carberry, et, al. (2013) on unmuddying course content using muddiest point reflection, which proved to have a positive impact on students' interest and achievement and the fact that many students want the muddiest point assessment technique to be continually used during instruction. It is therefore evident that muddiest point assessment technique proved to be more effective in enhancing students' achievement in Mathematics. The findings on the think-pair-share assessment technique is consistent with that of Hamdan (2017) who carried out a research work on the effect of think-pair-share on the achievement of third grade students in sciences in the education district of Irbid in Jordan and found a significant difference in the grades of students in favour of the think-pair-share technique. Furthermore, the findings on the think-pair-share assessment technique agrees with Akhtar and Saeed (2020b) who conducted a study on assessing the effect of agree/disagree, exist ticket and think-pair-share on students' academic achievement at undergraduate level and found among other things that there was a significant difference in the mean achievement scores of students assessed with think-pair-share assessment technique

and the other techniques in favour of think-pair-share assessment. The result of the think-pair-share assessment technique also strengthens earlier claims made by Sampsel (2013) who maintained that think-pair-share technique greatly improve students' confidence and participation. This is because students think about their response to a question, discuss their response in pair and share their response or ideas with larger group or class. However, the results of the study show that muddiest point assessment technique proved to be more effective than think-pair-share assessment technique.

The study showed that female students achieved slightly better than the male students when taught and assessed using forms of formative assessment technique. The study further revealed that gender does not significantly influence students' achievement in Mathematics when taught and assessed using forms of formative assessment techniques. This implies that students' gender is not a significant determinant of academic achievement in Mathematics. The finding of the study is consistent with Oluwatayo and James (2011) who conducted a study on gender difference in Mathematics of which the outcome showed no significant difference in the achievement of male and female students. This is in line with the research work by Ajai and Imoko (2015) on gender differences in Mathematics achievement and retention using Problem-Based Learning (PBL) which revealed no gender difference in students' Mathematics achievement and retention scores. The findings of this study reinforce the claim by Moyosore (2015) who concluded that when students are constantly introduced to formative assessment, there is no gender influences on academic their achievement. The finding of this study is in variance with a research work by Allahnana et, al. (2018) who found that male students excel in Mathematics more than their female counterparts. Also, a research work by Amalu (2017) found higher academic achievement in English language and Mathematics in favour of the female students. However, the finding of this study shows that there is no significant gender difference in students' academic achievement in Mathematics. This implies that students' achievement in Mathematics does not depend on whether the student is a male or female.

CONCLUSIONS

Students taught and assessed using muddiest point assessment technique achieved better than those taught and assessed using think-pair-share formative assessment technique. This result therefore shows that muddiest point formative assessment technique is more effective than the think-pair-share formative assessment technique which implies that the forms of formative assessment technique are effective in assessing students. There was significant difference in the mean achievement scores of students taught and assessed using think-pair-share and muddiest point formative assessment technique with those taught and assessed using muddiest point formative assessment having a higher mean gain. The difference in the mean achievement scores of male and female students in Mathematics was not statistically significant. Gender is not a significant factor in determining students' achievement in Mathematics. The findings of the study showed that the students taught and assessed using muddiest point formative assessment technique achieved better than those taught and assessed using think-pair-share formative assessment technique. This implies that the muddiest point formative assessment is more effective in improving students' achievement in Mathematics. The result of the study showed that the difference in the mean achievement scores of male and female students in Mathematics is not statistically significant. This implies that gender is not a significant factor in determining students' achievement in Mathematics.

LIMITATIONS OF THE STUDY

1. Even though the research assistants were trained on how to deliver the lesson that was incorporated with the assessment techniques, other intervening variables like mastery of content, intellectual abilities and teaching experience of the teachers were not totally controlled and these might have influenced the result of the study.
2. It is also possible that due to time frame, the research assistants might not have understood the instructional packages to the last details and as a result, the process of administration of the instructional packages could have not been followed effectively and that might have affected the outcome of the study.

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Appendix

MATHEMATICS ACHIEVEMENT TEST (M AT)

Section A: Demographic data of respondents

Please tick (✔) appropriately: Male ☐ **Female** ☐

Section B: Item statements
Instruction: Choose the correct answer from letter A-D by ticking (✔) the correct option.
Do not carry out rough work on this paper.
Time allowed: 1 hour, 35 minutes

1. A number which is 5 and above after a decimal point is rounded as…….
   (a) 0.5
   (b) 1
   (c) 0
   (d) 1.5
2. A number which is 4 or below after a decimal point is rounded as……..
   (a) 1.5
   (b) 0
   (c) 1
   (d) 0.5
3. Express 4764.457 to 1 and 2 decimal places
   (a) 4764.5 and 4760.50
   (b) 4764.5 and 4764.45
   (c) 4765.0 and 4764.46
   (d) 4764.5 and 4764.46
4. Round off 400,453 to the nearest thousand
   (A) 400,050
   (B) 400,000
   (C) 400,100
   (D) 401,000
5. Approximate 678,502, 453 to the nearest million
   (A) 679,000,000
   (B) 679,100,000
   (C) 678,000,000
   (D) 678,500,000
6. Round off 174,667,232,999 to the nearest billion
   (A) 174,000,000,000
   (B) 175,700,000,000
   (C) 175,000,000,000
   (D) 174, 700,000,000
7. Estimate 283,644,234,999,701 to the nearest trillion
   (A) 283,000,000,000,000
   (B) 283,000,000,010,000
   (C) 284,000,000,000,000
   (D) 284,100,000,000,000

8. A rope of length 11.8m was measured by a girl to be 10.9m. calculate the percentage error
   (A) 7.6%
   (B) 7.0%
   (C) 8.5%
   (D) 9.0%
9. A 3% error was committed by a carpenter in measurement of a ladder of actual length 45cm. Find the absolute error
   (A) 1.5
   (B) 1.0
   (C) 1.6
   (D) 1.8
10. The absolute error when Peter measured his father's staff is 2.4m and the percentage error is 15%. Calculate the actual length of the staff.
   (A) 15
   (B) 14
   (C) 12
   (D) 16
11. A chef underestimated his expenses by 3.5% but actually spent N400, what was his estimate?
   (A) N385
   (B) N380
   (C) N386
   (D) N384
12. How many hours to the nearest hour is in 4 hours 25 minutes
   (A) 5 hours
   (B) 6 hours
   (C) 4 hours
   (D) 7 hours
13. How many hours to the nearest hour is in 8 hours 45 minutes
   (A) 9 hours
   (B) 7 hours
   (C) 8 hours
   (D) 6 hours
14. A 3% error was made in the measurement of a wood of actual length 98cm. calculate the absolute error to the nearest whole number
   (A) 3cm
   (B) 4cm
   (C) 5cm
   (D) 3.1cm
15. Calculate the percentage error correctly to 1 decimal place if a bag of beans which weighed 15kg is recorded to have weighed 15.9kg
   (A) 6.0%
   (B) 6%
   (C) 6.1%
   (D) 6.10%
16. Arrange 23.02, 23.1 and 23.330 in ascending order
   (A) 23.02, 23.1 and 23.330
   (B) 23.1, 23.02 and 23.330
   (C) 23.330, 23.1 and 23.02
   (D) 23.1, 23.330 and 23.02
17. In a straight line graph, $\frac{y-axis}{x-axis}$ is referred to as ……..

(A) Intercept
(B) Graph line
(C) Slope
(D) Curve

18. The gradient of ……. Changes from point to point
(A) Line
(B) Straight line
(C) Curve
(D) Slope

19. The gradient of a straight line at any too points are always……..
(A) Straight
(B) Equal
(C) Different
(D) Curve

20. The gradient of the line described by the given points; X(8,4) and Y(10,6) is …….
(A) 0
(B) 2
(C) 3
(D) 1

21. Given the points; T(-4, 8) and J(8, -4), the gradient of the line is…….
(A) 1
(B) 0
(C) -2
(D) -1

22. A point where a line cut the y-axis is called……..
(A) Gradient
(B) Intercept
(C) Slope
(D) Curve

23. Given 4x+y = 14, the gradient of the equation is…….
(A) -4
(B) 4
(C) -5
(D) 5

24. If y_2 = 4, y_1=2, x_2=5 and x_1=1 calculate the slope
(A) $\frac{1}{3}$
(B) $\frac{1}{4}$
(C) $\frac{1}{2}$
(D) $-\frac{1}{3}$

25. What is the gradient and y-intercept of equation 8x-2y=10
(A) 4,5
(B) 4,-5
(C) -4,-5
(D) -4,5

26. Given that m =2, y_2=7, y_1 = -8, x_1 = -1.5, calculate the value for x_2
(A) -6.5
(B) 6.5
(C) -6
(D) 6

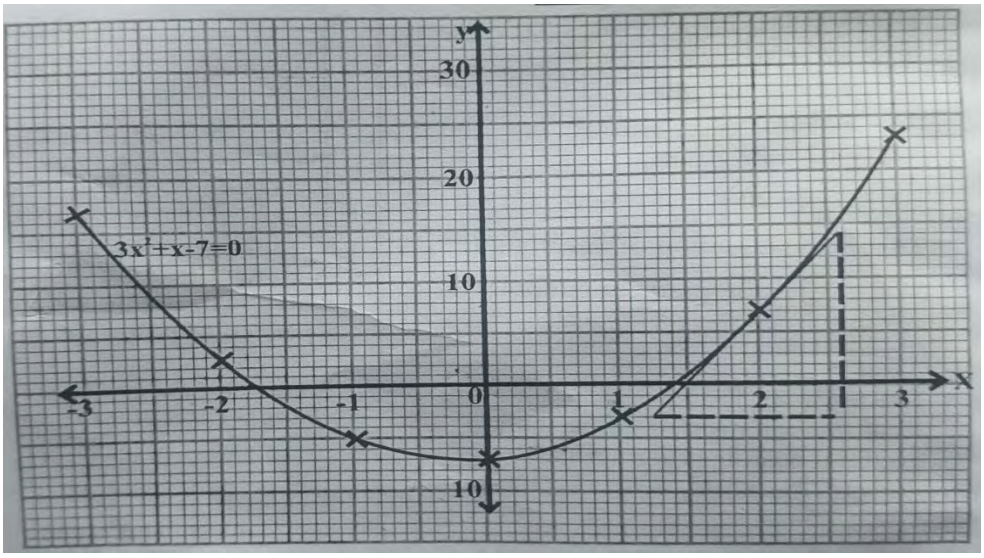
27. The equation of the line A(3,7) and B(4,9) is …….
    (A) y=2x-1
    (B) y=2x+1
    (C) y= 3x-2
    (D) y= 2x-2
28. The equation of a line with gradient 10 units which passes through (4,3) is …..
    (A) y=9x+36
    (B) y=10x-37
    (C) y=10x+37
    (D) y=-10x-37
29. A tangent of a curve is a straight line which is drawn to touch the … at a particular point.
    (A) Line
    (B) Curve
    (C) Graph
    (D) Intercept

Use the information in Table 1 and the Graph to answer question 30 to 34 given that $y = 3x^2 + x - 7$

X	-3	-2	-2	0	1	2	3
Y	P	3	Q	Z	W	7	23

Table 1.

30. Calculate the value of PQZW respectively
    (A) -17,5,-7,3
    (B) 17,-5,7,-3
    (C) 17,-5,-7,-3
    (D) -17,-5,7,-3



31. From the graph, determine the roots for the equation $y=3x^2 + x - 7$.
    (A) -1.4cm or -1.7cm
    (B) 1.4cm or 1.7cm
    (C) 1.4cm or -1.7cm
    (D) -1.4cm or 1.7cm
32. What is the scale on the graph for y-axis

(A) 2cm:10units
(B) 10cm:10units
(C) 10cm:2units
(D) 2cm:2units

33. The least value for the equation y=3x^2 + x -7 is ……
(A) -7.0
(B) -7
(C) 7.01
(D) 7.0

34. The gradient of the graph at the point when x = 2 and y = 7 is……..
(A) $12\frac{1}{6}$
(B) $11\frac{1}{7}$
(C) $-12\frac{1}{7}$
(D) $12\frac{1}{7}$

35. The difference between the highest value and lowest value in a given set of numbers is…
(A) Range
(B) Mean deviation
(C) Variance
(D) Standard deviation

36. The extent to which variation in a given distribution is shown is referred to as…….
(A) Range
(B) Mean deviation
(C) Variance
(D) Standard deviation

37. The individual spread of numbers in a set of numbers from a mean is known as…….
(A) Central tendency
(B) Deviation
(C) Range
(D) Assume mean

Given the data 2,4,6,8,10. Use the data to answer question 38 to 41

38. What is the range of the distribution
(A) 7
(B) 8
(C) 6
(D) 5

39. What is the sum of the deviation from the mean
(A) 1
(B) 0
(C) -1
(D) 2

40. The variance of the distribution is……
(A) 6.7
(B) 8
(C) 9
(D) 7

41. The standard deviation to 1 decimal place using the value of variance in question 40 is…
(A) 2.8
(B) 2.6
(C) 2.5
(D) 2.3

Elizabeth measured some cups of rice as follows; 2 cups, 4 cups, 8 cups and 10 cups. Use the information to answer question 42 to 45.

42. The range of the measurement is …..
    (A) 8 cups
    (B) 8
    (C) 8 cup
    (D) 7 cups
43. The variance in measurement to the nearest whole number is….
    (A) 10
    (B) 12 cup
    (C) 10 cups
    (D) 11 cups
44. The standard deviation in the measurement to 1 decimal place is….
    (A) 3.1
    (B) 3.0
    (C) 3.2
    (D) 4
45. The difference between range and standard deviation to the nearest whole number is...
    (A) 5
    (B) 4
    (C) -4
    (D) -5

Given the data 3,1,4,2,5,6,7,9,10,8,12, 11 Use the information to answer question 46 to 50.

46. Calculate the value for the first quartile
    (A) 4.5
    (B) 6.5
    (C) 9.5
    (D) 3.5
47. Calculate the value for the third quartile
    (A) 5.5
    (B) 7.5
    (C) 4.5
    (D) 9.5
48. The sum of the first quartile and the third quartile is …..
    (A) 13
    (B) 12
    (C) 14
    (D) 11
49. What is the value for the inter-quartile range
    (A) 6
    (B) 7
    (C) 5
    (D) 4
50. The semi-inter quartile range to the nearest whole number is ….
    (A) 4
    (B) 5
    (C) 3
    (D) 2